R&S®FSW-K91
WLAN Measurements
User Manual

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Test & Measurement

User Manual

ROHDE&SCHWARZ

This manual applies to the following R&S®FSW models with firmware version 1.70 and higher:

- R&S®FSW8 (1312.8000K08)
- R&S®FSW13 (1312.8000K13)
- R&S®FSW26 (1312.8000K26)
- R&S®FSW43 (1312.8000K43)
- R&S®FSW50 (1312.8000K50)

The following firmware options are described:

- R&S FSW-K91 WLAN 802.11a (1313.1500.02)
- R&S FSW-K91ac WLAN 802.11ac (1313.4209.02)
- R&S FSW-K91n WLAN 802.11n (1313.1516.02)

The firmware of the instrument makes use of several valuable open source software packages. For information, see the "Open Source Acknowledgement" on the user documentation CD-ROM (included in delivery).
Rohde & Schwarz would like to thank the open source community for their valuable contribution to embedded computing.

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The following abbreviations are used throughout this manual: R&S®FSW is abbreviated as R&S FSW.

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1 Preface

1.1 About this Manual

This WLAN User Manual provides all the information **specific to the application**. All general instrument functions and settings common to all applications and operating modes are described in the main R&S FSW User Manual.

The main focus in this manual is on the measurement results and the tasks required to obtain them. The following topics are included:

- chapter 2, "Welcome to the WLAN Application", on page 9
  Introduction to and getting familiar with the application
- chapter 3, "Measurements and Result Displays", on page 13
  Details on supported measurements and their result types
- chapter 4, "Measurement Basics", on page 45
  Background information on basic terms and principles in the context of the measurement
- chapter 5, "Configuration", on page 66 and chapter 6, "Analysis", on page 119
  A concise description of all functions and settings available to configure measurements and analyze results with their corresponding remote control command
- chapter 5.3.13, "Import/Export Functions", on page 114
  Description of general functions to import and export raw I/Q (measurement) data
- chapter 7, "How to Perform Measurements in the WLAN Application", on page 120
  The basic procedure to perform each measurement and step-by-step instructions for more complex tasks or alternative methods
- chapter 8, "Optimizing and Troubleshooting the Measurement", on page 123
  Hints and tips on how to handle errors and optimize the test setup
- chapter 9, "Remote Commands for WLAN Measurements", on page 126
  Remote commands required to configure and perform WLAN measurements in a remote environment, sorted by tasks
  (Commands required to set up the environment or to perform common tasks on the instrument are provided in the main R&S FSW User Manual)
  Programming examples demonstrate the use of many commands and can usually be executed directly for test purposes
- chapter A, "Annex: Reference", on page 230
  Reference material
- **List of remote commands**
  Alpahabetical list of all remote commands described in the manual
- **Index**

1.2 Documentation Overview

The user documentation for the R&S FSW consists of the following parts:

- "Getting Started" printed manual
- Online Help system on the instrument
- Documentation CD-ROM with:
  - Getting Started
  - User Manuals for base unit and options
  - Service Manual
  - Release Notes
  - Data sheet and product brochures

Online Help

The Online Help is embedded in the instrument's firmware. It offers quick, context-sensitive access to the complete information needed for operation and programming. Online help is available using the icon on the toolbar of the R&S FSW.

Getting Started

This manual is delivered with the instrument in printed form and in PDF format on the CD. It provides the information needed to set up and start working with the instrument. Basic operations and handling are described. Safety information is also included.

The Getting Started manual in various languages is also available for download from the R&S website, on the R&S FSW product page at http://www2.rohde-schwarz.com/product/FSW.html.

User Manuals

User manuals are provided for the base unit and each additional (software) option.

The user manuals are available in PDF format - in printable form - on the Documentation CD-ROM delivered with the instrument. In the user manuals, all instrument functions are described in detail. Furthermore, they provide a complete description of the remote control commands with programming examples.

The user manual for the base unit provides basic information on operating the R&S FSW in general, and the Spectrum application in particular. Furthermore, the software functions that enhance the basic functionality for various applications are described here. An introduction to remote control is provided, as well as information on maintenance, instrument interfaces and troubleshooting.

In the individual application manuals, the specific instrument functions of the application are described in detail. For additional information on default settings and parameters, refer to the data sheets. Basic information on operating the R&S FSW is not included in the application manuals.

All user manuals are also available for download from the R&S website, on the R&S FSW product page at http://www2.rohde-schwarz.com/product/FSW.html.

Service Manual

This manual is available in PDF format on the CD delivered with the instrument. It describes how to check compliance with rated specifications, instrument function, repair, troubleshooting and fault elimination. It contains all information required for repairing the R&S FSW by replacing modules.

Release Notes

The release notes describe the installation of the firmware, new and modified functions, eliminated problems, and last minute changes to the documentation. The corresponding firmware version is indicated on the title page of the release notes.

The most recent release notes are also available for download from the R&S website, on the R&S FSW product page at http://www2.rohde-schwarz.com/product/FSW.html > Downloads > Firmware.

1.3 Conventions Used in the Documentation

1.3.1 Typographical Conventions

The following text markers are used throughout this documentation:

Convention	Description
"Graphical user interface elements"	All names of graphical user interface elements on the screen, such as dialog boxes, menus, options, buttons, and softkeys are enclosed by quotation marks.
KEYS	Key names are written in capital letters.
`File names, commands, program code`	File names, commands, coding samples and screen output are distinguished by their font.
Input	Input to be entered by the user is displayed in italics.
Links	Links that you can click are displayed in blue font.
"References"	References to other parts of the documentation are enclosed by quotation marks.

1.3.2 Conventions for Procedure Descriptions

When describing how to operate the instrument, several alternative methods may be available to perform the same task. In this case, the procedure using the touchscreen is described. Any elements that can be activated by touching can also be clicked using an additionally connected mouse. The alternative procedure using the keys on the instrument or the on-screen keyboard is only described if it deviates from the standard operating procedures.

The term "select" may refer to any of the described methods, i.e. using a finger on the touchscreen, a mouse pointer in the display, or a key on the instrument or on a keyboard.

2 Welcome to the WLAN Application

The R&S FSW WLAN application extends the functionality of the R&S FSW to enable accurate and reproducible Tx measurements of a WLAN device under test (DUT) in accordance with the standards specified for the device. the following standards are currently supported:

- IEEE standards 802.11a
- IEEE standards 802.11ac
- IEEE standards 802.11b
- IEEE standards 802.11g (OFDM)
- IEEE standards 802.11g (DSSS)
- IEEE standards 802.11n (SISO)

The R&S FSW WLAN application features:

Modulation measurements

- Constellation diagram for demodulated signal
- Constellation diagram for individual carriers
- I/Q offset and I/Q imbalance
- Modulation error (EVM) for individual carriers or symbols
- Amplitude response and group-delay distortion (spectrum flatness)

Further measurements and results

- Amplitude statistics (CCDF) and crest factor
- FFT, also over a selected part of the signal, e.g. preamble
- Payload bit information

This user manual contains a description of the functionality that is specific to the application, including remote control operation.

All functions not discussed in this manual are the same as in the base unit and are described in the R&S FSW User Manual. The latest version is available for download at the product homepage.

Installation

You can find detailed installation instructions in the R&S FSW Getting Started manual or in the Release Notes.

2.1 Starting the WLAN Application

The WLAN measurements require a special application on the R&S FSW.

To activate the WLAN application

1. Press the MODE key on the front panel of the R&S FSW.

A dialog box opens that contains all operating modes and applications currently available on your R&S FSW.

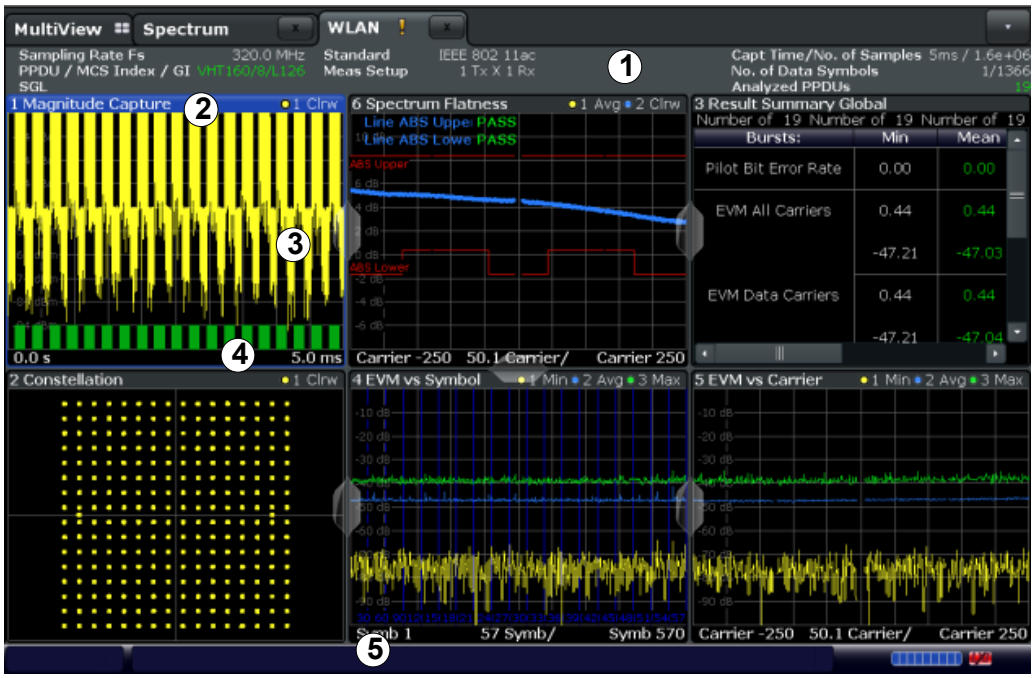
2. Select the "WLAN" item.

The R&S FSW opens a new measurement channel for the WLAN application.

The measurement is started immediately with the default settings. It can be configured in the WLAN "Overview" dialog box, which is displayed when you select the "Overview" softkey from any menu (see chapter 5.3.2, "Configuration Overview", on page 70).

2.2 Understanding the Display Information

The following figure shows a measurement diagram during analyzer operation. All information areas are labeled. They are explained in more detail in the following sections.



1 = Channel bar for firmware and measurement settings
2 = Window title bar with diagram-specific (trace) information
3 = Diagram area with marker information
4 = Diagram footer with diagram-specific information, depending on result display
5 = Instrument status bar with error messages, progress bar and date/time display

Channel bar information

In the WLAN application, the R&S FSW shows the following settings:

Table 2-1: Information displayed in the channel bar in the WLAN application

Label	Description
Sample Rate Fs	Input sample rate
PPDU / MCS Index / GI	WLAN 802.11**a,ac,n**: The PPDU type, MCS Index and Guard Interval used for the analysis of the signal; Depending on the demodulation settings, these values are either detected automatically from the signal or the user settings are applied.
PPDU / Data Rate	WLAN 802.11**b**: The PPDU type and data rate used for the analysis of the signal; Depending on the demodulation settings, these values are either detected automatically from the signal or the user settings are applied.
Standard	Selected WLAN measurement standard
Meas Setup	Number of Transmitter (Tx) and Receiver (Rx) channels used in the measurement (currently always 1 Tx+1 Rx)
Capt time / No. of Samples	Duration of signal capture and number of samples captured
No. of Data Symbols	The minimum and maximum number of data symbols that a PPDU may have if it is to be considered in results analysis.
Analyzed PPDUs [x of y (z)]	For statistical evaluation over PPDUs (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 109): <x> PPDUs of totally required <y> PPDUs have been analyzed so far. <z> PPDUs were analyzed in the most recent sweep.

In addition, the channel bar also displays information on instrument settings that affect the measurement results even though this is not immediately apparent from the display of the measured values (e.g. transducer or trigger settings). This information is displayed only when applicable for the current measurement. For details see the R&S FSW Getting Started manual.

Window title bar information

For each diagram, the header provides the following information:

Fig. 2-1: Window title bar information in the WLAN application

1 = Window number
2 = Window type
3 = Trace color
4 = Trace number
6 = Trace mode

Diagram footer information

The diagram footer (beneath the diagram) contains the start and stop values for the displayed x-axis range.

Status bar information

Global instrument settings, the instrument status and any irregularities are indicated in the status bar beneath the diagram. Furthermore, the progress of the current operation is displayed in the status bar. Click on a displayed warning or error message to obtain more details (see also .

3 Measurements and Result Displays

The R&S FSW WLAN application provides several different measurements in order to determine the parameters described by the WLAN 802.11 specifications.

For details on selecting measurements see "Selecting the measurement type" on page 66.

Note for R&S FSV and R&S FSQ users

In comparison to the WLAN applications for R&S FSV and R&S FSQ spectrum analyzers, the following measurements and result displays are not (yet) available:

- MIMO measurements
- Power vs time for rising/falling edges
- Frequency error vs preamble
- Phase error vs preamble

- WLAN I/Q Measurement (Modulation Accuracy, Flatness and Tolerance).....13
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3.1 WLAN I/Q Measurement (Modulation Accuracy, Flatness and Tolerance)

The default WLAN I/Q measurement captures the I/Q data from the WLAN signal using a (nearly rectangular) filter with a relatively large bandwidth. The I/Q data captured with this filter includes magnitude and phase information, which allows the R&S FSW WLAN application to demodulate broadband signals and determine various characteristic signal parameters such as the modulation accuracy, spectrum flatness, center frequency tolerance and symbol clock tolerance in just one measurement.

Other parameters specified in the WLAN 802.11 standard require a better signal-to-noise level or a smaller bandwidth filter than the I/Q measurement provides and must be determined in separate measurements (see chapter 3.2, "Frequency Sweep Measurements", on page 39).

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3.1.1 Modulation Accuracy, Flatness and Tolerance Parameters

The default WLAN I/Q measurement (Modulation Accuracy, Flatness,...) captures the I/Q data from the WLAN signal and determines all the following I/Q parameters in a single sweep.

Table 3-1: WLAN I/Q parameters for IEEE 802.11a, g (OFDM), ac ,n

Parameter	Description
Sample Rate Fs	Input sample rate
PPDU	Type of analyzed PPDUs
MCS Index	Modulation and Coding Scheme (MCS) index of the analyzed PPDUs
GI	Guard interval length for current measurement
Standard	Selected WLAN measurement standard
Meas Setup	Number of Transmitter (Tx) and Receiver (Rx) channels used in the measurement
Capture time	Duration of signal capture
No. of Samples	Number of samples captured
No. of Data Symbols	The minimum and maximum number of data symbols that a PPDU may have if it is to be considered in results analysis.
Analyzed PPDUs	For statistical evaluation of PPDUs (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 109): <x> PPDUs of totally required <y> PPDUs have been analyzed so far. <z> indicates the number of analyzed PPDUs in the most recent sweep.
Number of recognized PPDUs (global)	Number of PPDUs recognized in capture buffer
Number of analyzed PPDUs (global)	Number of analyzed PPDUs in capture buffer
Number of analyzed PPDUs in physical channel	Number of PPDUs analyzed in entire signal (if available)
Pilot bit error rate [%]	
EVM all carriers [%/dB]	EVM (Error Vector Magnitude) of the payload symbols over all carriers; the corresponding limits specified in the standard are also indicated***)**
EVM data carriers [%/dB]	EVM (Error Vector Magnitude) of the payload symbols over all data carriers; the corresponding limits specified in the standard are also indicated***)**
EVM pilot carriers [%/dB]	EVM (Error Vector Magnitude) of the payload symbols over all pilot carriers; the corresponding limits specified in the standard are also indicated***)**
Center frequency error [Hz]	Frequency error between the signal and the current center frequency of the R&S FSW; the corresponding limits specified in the standard are also indicated***)** The absolute frequency error includes the frequency error of the R&S FSW and that of the DUT. If possible, the transmitterR&S FSW and the DUT should be synchronized (using an external reference). See R&S FSW User Manual > Instrument setup > External reference
***)** the limits can be changed via remote control (not manually, see chapter 9.5.9, "Limits", on page 178); in this case, the currently defined limits are displayed here	

Parameter	Description
Symbol clock error [ppm]	Clock error between the signal and the sample clock of the R&S FSW in parts per million (ppm), i.e. the symbol timing error; the corresponding limits specified in the standard are also indicated ***)** If possible, the transmitterR&S FSW and the DUT should be synchronized (using an external reference). See R&S FSW User Manual > Instrument setup > External reference
I/Q offset [dB]	Transmitter center frequency leakage relative to the total Tx channel power (see chapter 3.1.1.1, "I/Q Offset", on page 17)
Gain imbalance [%/dB]	Amplification of the quadrature phase component of the signal relative to the amplification of the in-phase component (see chapter 3.1.1.2, "Gain Imbalance", on page 17)
Quadrature offset [°]	Deviation of the quadrature phase angle from the ideal 90° (see chapter 3.1.1.3, "Quadrature Offset", on page 18).
PPDU power [dBm]	Mean PPDU power
Crest factor [dB]	The ratio of the peak power to the mean power of the signal (also called Peak to Average Power Ratio, PAPR).
***)** the limits can be changed via remote control (not manually, see chapter 9.5.9, "Limits", on page 178); in this case, the currently defined limits are displayed here	

Table 3-2: WLAN I/Q parameters for IEEE 802.11b or g (DSSS)

Parameter	Description
Sample Rate Fs	Input sample rate
PPDU	Type of the analyzed PPDU
Data Rate	Data rate used for analysis of the signal
SGL	Indicates single measurement mode (as opposed to continuous)
Standard	Selected WLAN measurement standard
Meas Setup	Number of Transmitter (Tx) and Receiver (Rx) channels used in the measurement
Capture time	Duration of signal capture
No. of Samples	Number of samples captured (= sample rate * capture time)
No. of Data Symbols	The minimum and maximum number of data symbols that a PPDU may have if it is to be considered in results analysis
Analyzed PPDUs	For statistical evaluation of PPDUs (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 109): <x> PPDUs of totally required <y> PPDUs have been analyzed so far. <z> indicates the number of analyzed PPDUs in the most recent sweep.
Number of recognized PPDUs (global)	Number of PPDUs recognized in capture buffer
Number of analyzed PPDUs (global)	Number of analyzed PPDUs in capture buffer
Number of analyzed PPDUs in physical channel	Number of PPDUs analyzed in entire signal (if available)

Parameter	Description
Peak vector error	Peak vector error (EVM) over the complete PPDU including the preamble in % and in dB; calculated according to the IEEE 802.11b or g (DSSS) definition of the normalized error vector magnitude (see "Peak Vector Error (IEEE method)" on page 21); The corresponding limits specified in the standard are also indicated ***)**
PPDU EVM	EVM (Error Vector Magnitude) over the complete PPDU including the preamble in % and dB
I/Q offset [dB]	Transmitter center frequency leakage relative to the total Tx channel power (see chapter 3.1.1.1, "I/Q Offset", on page 17)
Gain imbalance [%/dB]	Amplification of the quadrature phase component of the signal relative to the amplification of the in-phase component (see chapter 3.1.1.2, "Gain Imbalance", on page 17)
Quadrature error [°]	Measure for the crosstalk of the Q-branch into the I-branch (see "Gain imbalance, I/Q offset, quadrature error" on page 56).
Center frequency error [Hz]	Frequency error between the signal and the current center frequency of the R&S FSW; the corresponding limits specified in the standard are also indicated***)** The absolute frequency error includes the frequency error of the R&S FSW and that of the DUT. If possible, the transmitterR&S FSW and the DUT should be synchronized (using an external reference). See R&S FSW User Manual > Instrument setup > External reference
Chip clock error [ppm]	Clock error between the signal and the chip clock of the R&S FSW in parts per million (ppm), i.e. the chip timing error; the corresponding limits specified in the standard are also indicated ***)** If possible, the transmitterR&S FSW and the DUT should be synchronized (using an external reference). See R&S FSW User Manual > Instrument setup > External reference
Rise time	Time the signal needs to increase its power level from 10% to 90% of the maximum or the average power (depending on the reference power setting) The corresponding limits specified in the standard are also indicated ***)**
Fall time	Time the signal needs to decrease its power level from 90% to 10% of the maximum or the average power (depending on the reference power setting) The corresponding limits specified in the standard are also indicated ***)**
Mean power [dBm]	Mean PPDU power
Peak power [dBm]	Peak PPDU power
Crest factor [dB]	The ratio of the peak power to the mean power of the PPDU (also called Peak to Average Power Ratio, PAPR).

The R&S FSW WLAN application also performs statistical evaluation over several PPDUs and displays one or more of the following results:

Table 3-3: Calculated summary results

Result type	Description
Min	Minimum measured value
Mean/ Limit	Mean measured value / limit defined in standard
Max/Limit	Maximum measured value / limit defined in standard

3.1.1.1 I/Q Offset

An I/Q offset indicates a carrier offset with fixed amplitude. This results in a constant shift of the I/Q axes. The offset is normalized by the mean symbol power and displayed in dB.

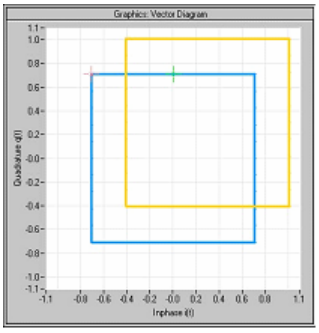

Fig. 3-1: I/Q offset in a vector diagram

3.1.1.2 Gain Imbalance

An ideal I/Q modulator amplifies the I and Q signal path by exactly the same degree. The imbalance corresponds to the difference in amplification of the I and Q channel and therefore to the difference in amplitude of the signal components. In the vector diagram, the length of the I vector changes relative to the length of the Q vector.

The result is displayed in dB and %, where 1 dB offset corresponds to roughly 12 % difference between the I and Q gain, according to the following equation:

$Imbalance\ [dB] = 20log\ (|\ Gain_Q\ |/|\ Gain_I\ |)$

Positive values mean that the Q vector is amplified more than the I vector by the corresponding percentage. For example using the figures mentioned above:

0.98 ≈ 20*log10(1.12/1)

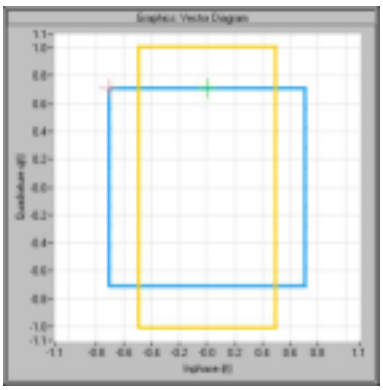

Fig. 3-2: Positive gain imbalance

Negative values mean that the I vector is amplified more than the Q vector by the corresponding percentage. For example using the figures mentioned above:

-0.98 ≈ 20*log10(1/1.12)

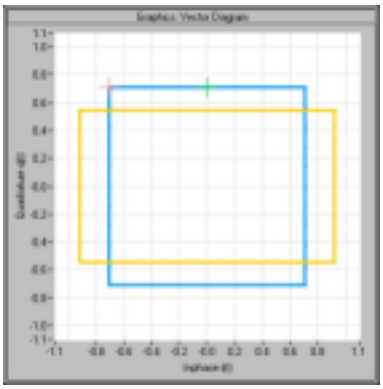

Fig. 3-3: Negative gain imbalance

3.1.1.3 Quadrature Offset

An ideal I/Q modulator sets the phase angle between the I and Q path mixer to exactly 90 degrees. With a quadrature offset, the phase angle deviates from the ideal 90 degrees, the amplitudes of both components are of the same size. In the vector diagram, the quadrature offset causes the coordinate system to shift.

A positive quadrature offset means a phase angle greater than 90 degrees:

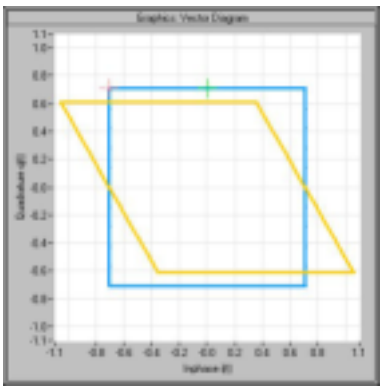

Fig. 3-4: Positive quadrature offset

A negative quadrature offset means a phase angle less than 90 degrees:

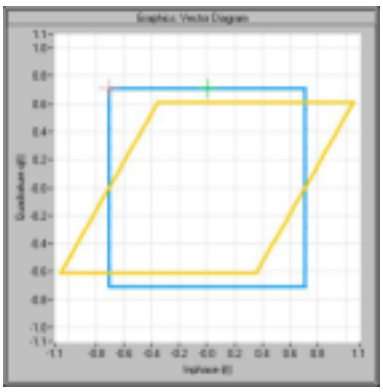

Fig. 3-5: Negative quadrature offset

3.1.1.4 RF Carrier Suppression (IEEE 802.11b, g (DSSS))

Standard definition

The RF carrier suppression, measured at the channel center frequency, shall be at least 15 dB below the peak SIN(x)/x power spectrum. The RF carrier suppression shall be measured while transmitting a repetitive 01 data sequence with the scrambler disabled using DQPSK modulation. A 100 kHz resolution bandwidth shall be used to perform this measurement.

Comparison to IQ offset measurement in the R&S FSW WLAN application

The IQ offset measurement in the R&S FSW WLAN application returns the current carrier feedthrough normalized to the mean power at the symbol timings. This measurement does not require a special test signal and is independent of the transmit filter shape.

The RF carrier suppression measured according to the standard is inversely proportional to the IQ offset measured in the R&S FSW WLAN application. The difference (in dB) between the two values depends on the transmit filter shape and should be determined with a reference measurement.

The following table lists the difference exemplarily for three transmit filter shapes (±0.5 dB):

Transmit filter	– IQ-Offset [dB] – RF-Carrier-Suppression [dB]
Rectangular	11 dB
Root raised cosine, "□" = 0.3	10 dB
Gaussian, "□" = 0.3	9 dB

3.1.1.5 EVM Measurement

The R&S FSW WLAN application provides two different types of EVM calculation.

PPDU EVM (Direct method)

The PPDU EVM (direct) method evaluates the root mean square EVM over one PPDU. That is the square root of the averaged error power normalized by the averaged reference power:

$$EVM = \sqrt{\frac{\sum_{n=0}^{N-1} \left| x_{meas}(n) - x_{ref}(n) \right|^2}{\sum_{n=0}^{N-1} \left| x_{ref}(n) \right|^2}} = \sqrt{\frac{\sum_{n=0}^{N-1} \left| e(n) \right|^2}{\sum_{n=0}^{N-1} \left| x_{ref}(n) \right|^2}}$$

Before calculation of the EVM, tracking errors in the measured signal are compensated for if specified by the user. In the ideal reference signal, the tracking errors are always compensated for. Tracking errors include phase (center frequency error + common phase error), timing (sampling frequency error) and gain errors. quadrature offset and gain imbalance errors, however, are not corrected.

The PPDU EVM is not part of the IEEE standard and no limit check is specified. Nevertheless, this commonly used EVM calculation can provide some insight in modulation quality and enables comparisons to other modulation standards.

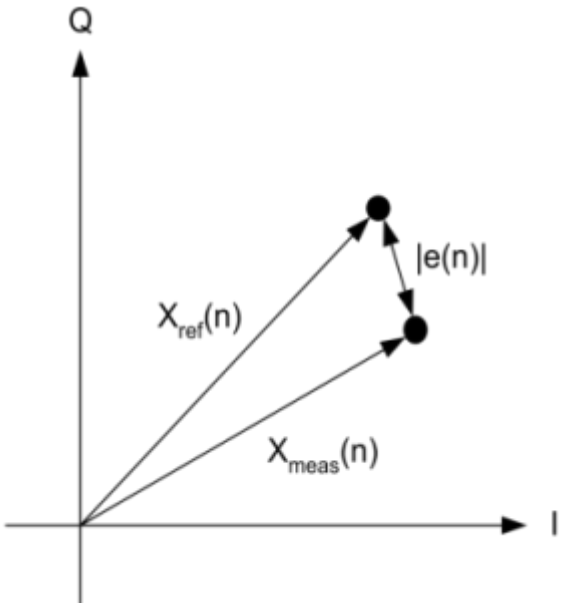

Fig. 3-6: I/Q diagram for EVM calculation

Peak Vector Error (IEEE method)

The peak vector error (Peak EVM) is defined in section 18.4.7.8 "Transmit modulation accuracy" of the IEEE 802.11b standard. The phase, timing and gain tracking errors of the measurement signal (center frequency error, common phase error, sampling frequency error) are compensated for before EVM calculation.

The standard does not specify a normalization factor for the error vector magnitude. To get an EVM value that is independent of the level, the R&S FSW WLAN application normalizes the EVM values. Thus, an EVM of 100% indicates that the error power on the I- or Q-channels equals the mean power on the I- or Q-channels, respectively.

The peak vector error is the maximum EVM over all payload symbols and all active carriers for one PPDU. If more than one PPDU is analyzed (several analyzed PPDUs in the capture buffer or due to the PPDU Statistic Count / No of PPDUs to Analyze setting), the Min / Mean / Max columns show the minimum, mean or maximum Peak EVM of all analyzed PPDUs.

The IEEE 802.11b or g (DSSS) standards allow a peak vector error of less than 35%. In contrary to the specification, the R&S FSW WLAN application does not limit the measurement to 1000 chips length, but searches the maximum over the whole PPDU.

3.1.2 Evaluation Methods for WLAN IQ Measurements

The captured I/Q data from the WLAN signal can be evaluated using various different methods without having to start a new measurement or sweep. Which results are displayed depends on the selected evaluation.

The selected evaluation method not only affects the result display in a window, but also the results of the trace data query in remote control (see `TRACe<n>[:DATA]` on page 210).

All evaluations available for the selected WLAN measurement are displayed in SmartGrid mode.

To activate SmartGrid mode, do one of the following:

-

  Select the "SmartGrid" icon from the toolbar.
- Select the "Display Config" button in the configuration "Overview" (see chapter 5.2, "Display Configuration", on page 68).
- Press the MEAS CONFIG hardkey and then select the "Display Config" softkey.

To close the SmartGrid mode and restore the previous softkey menu select the "Close" icon in the righthand corner of the toolbar, or press any key on the front panel.

The WLAN measurements provide the following evaluation methods:

Bitstream....22
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EVM vs Chip....27
EVM vs Symbol....27
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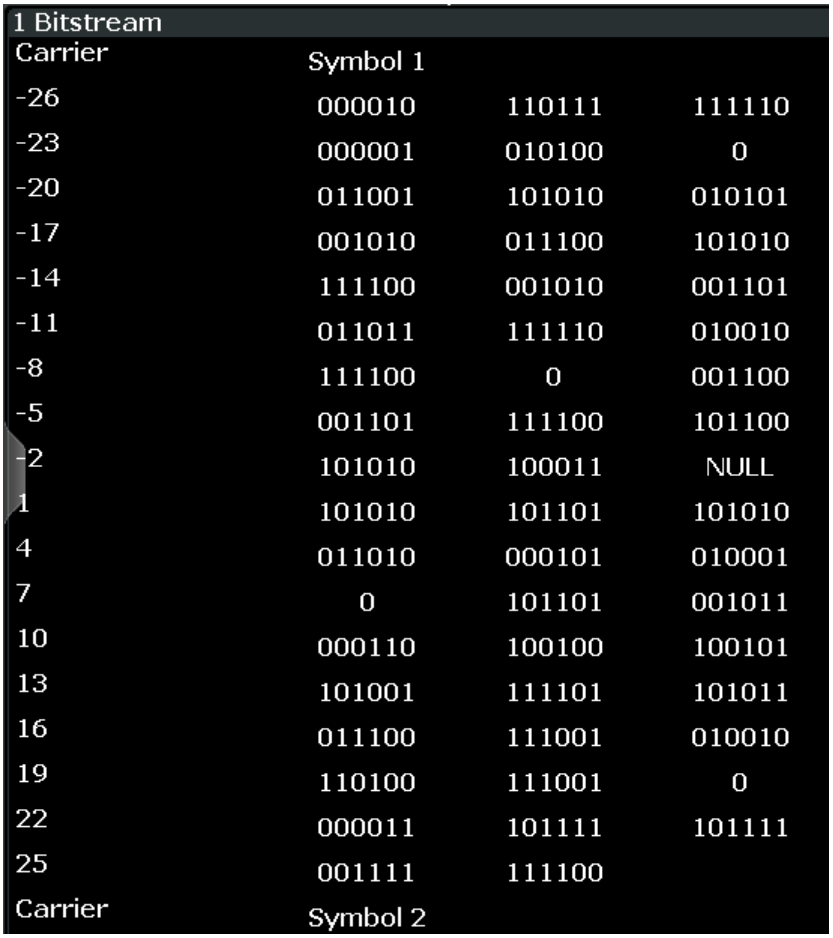
Bitstream
This result display shows the demodulated payload data stream for all analyzed PPDUs of the currently captured I/Q data as indicated in the "Magnitude Capture" display. The bitstream is derived from the constellation diagram points using the 'constellation bit encoding' from the corresponding WLAN standard. See for example *IEEE Std. 802.11-2012 'Fig. 18-10 BPSK, QPSK, 16-QAM and 64-QAM constellation bit encoding'*. Thus, the bitstream is *NOT* channel-decoded.

For multicarrier measurements (**IEEE 802.11a, g (OFDM), ac, n**) the results are grouped by symbol and carrier.



1 Bitstream

Carrier	Symbol 1		
-26	000010	110111	111110
-23	000001	010100	0
-20	011001	101010	010101
-17	001010	011100	101010
-14	111100	001010	001101
-11	011011	111110	010010
-8	111100	0	001100
-5	001101	111100	101100
-2	101010	100011	NULL
1	101010	101101	101010
4	011010	000101	010001
7	0	101101	001011
10	000110	100100	100101
13	101001	111101	101011
16	011100	111001	010010
19	110100	111001	0
22	000011	101111	101111
25	001111	111100	
Carrier	Symbol 2		

Fig. 3-7: Bitstream result display for IEEE 802.11a, g (OFDM), ac, n standards

For single-carrier measurements (**IEEE 802.11b, g (DSSS)**) the results are grouped by PPDU.

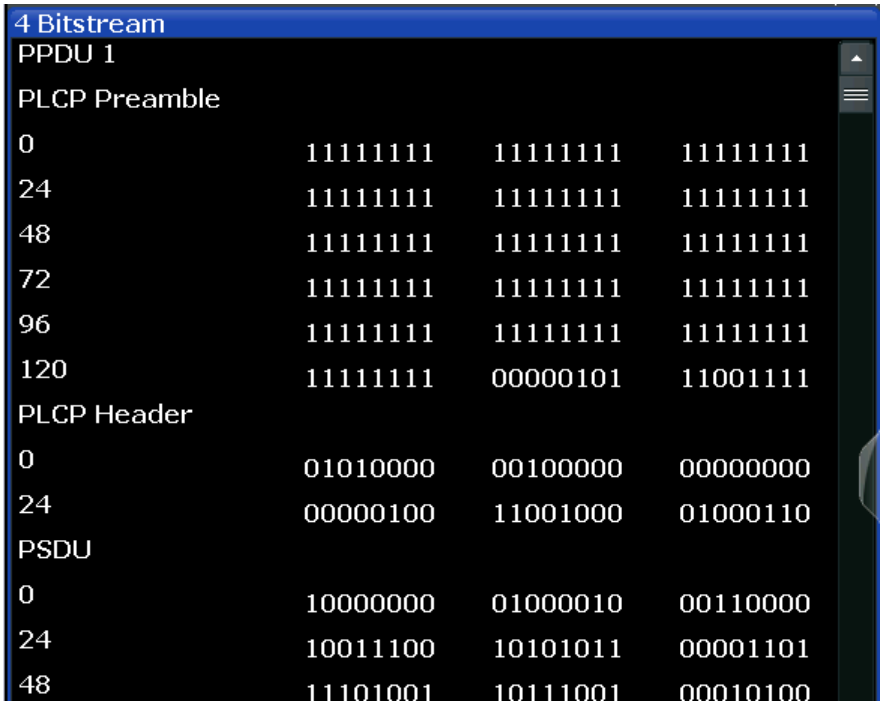


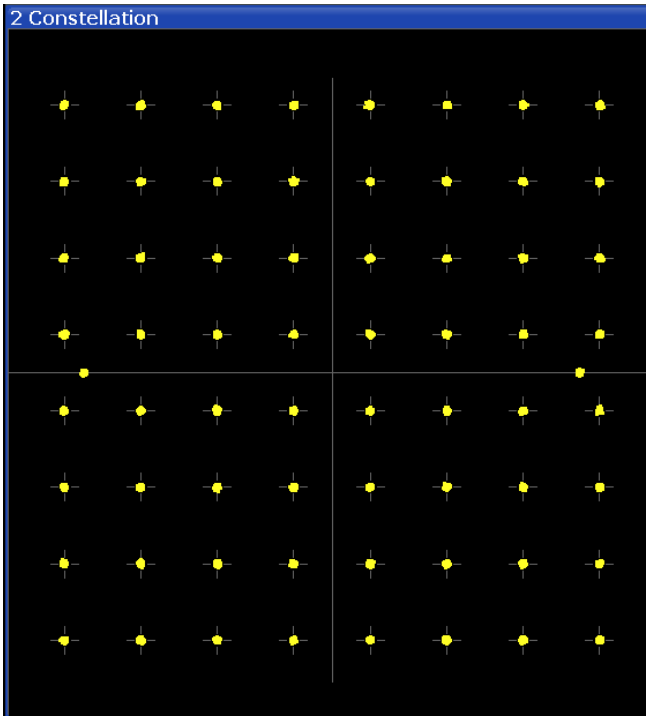
Fig. 3-8: Bitstream result display for IEEE 802.11b, g (DSSS) standards

The numeric trace results for this evaluation method are described in chapter 9.9.4.1, "Bitstream", on page 216.

Remote command:
`LAY:ADD? '1',RIGH, BITS`, see `LAYout:ADD[:WINDow]?` on page 186
or:
`CONFigure:BURSt:STATistics:BSTReam[:IMMediate]` on page 139

Constellation
This result display shows the in-phase and quadrature phase results for all payload symbols and all carriers for the analyzed PPDUs of the current capture buffer. The Tracking/ Channel Estimation according to the user settings is applied.

The inphase results (I) are displayed on the x-axis, the quadrature phase (Q) results on the y-axis.



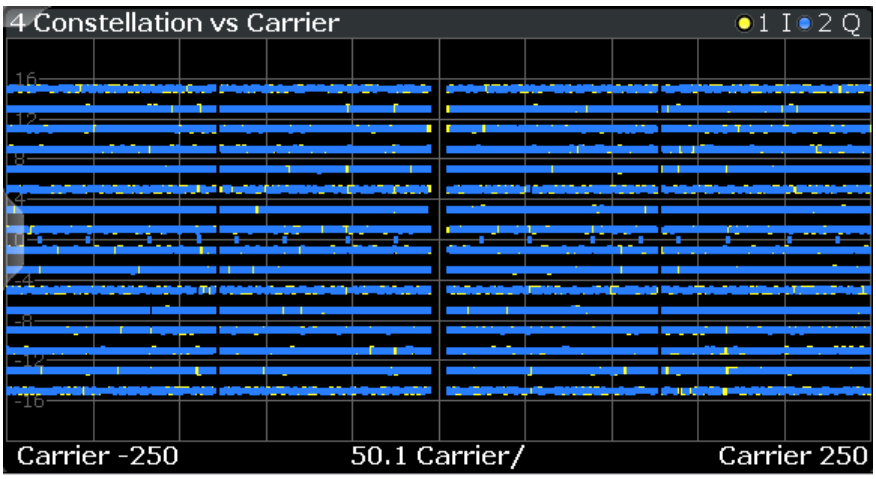
The numeric trace results for this evaluation method are described in chapter 9.9.4.3, "Constellation", on page 216.

Remote command:
`LAY:ADD? '1',RIGH, CONS`, see `LAYout:ADD[:WINDow]?` on page 186
or:
`CONFigure:BURSt:CONSt:CSYMbol[:IMMediate]` on page 137

Constellation vs Carrier
This result display shows the in-phase and quadrature phase results for all payload symbols and all carriers for the analyzed PPDUs of the current capture buffer. The Tracking/ Channel Estimation according to the user settings is applied.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

The x-axis represents the carriers. The magnitude of the in-phase and quadrature part is shown on the y-axis, both are displayed as separate traces (I-> trace 1, Q-> trace 2).

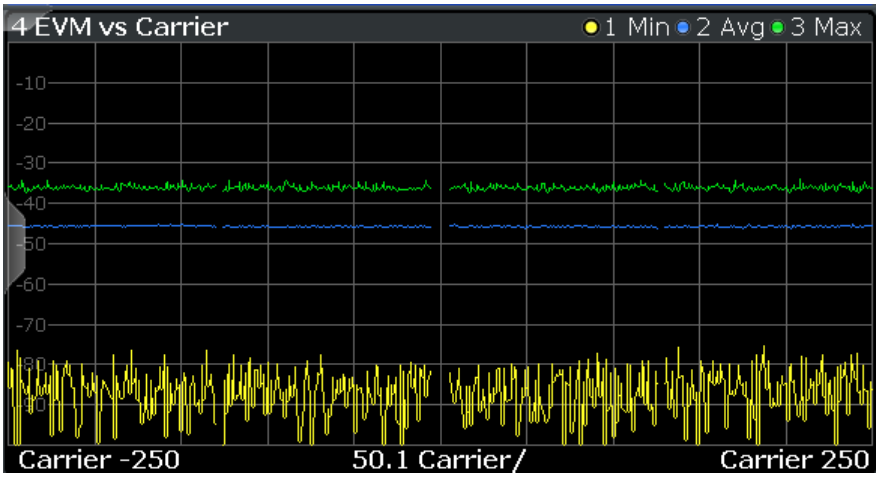


The numeric trace results for this evaluation method are described in chapter 9.9.4.4, "Constellation vs Carrier", on page 217.

Remote command:
`LAY:ADD? '1',RIGH, CVC`, see `LAYout:ADD[:WINDow]?` on page 186
or:
`CONFigure:BURSt:CONSt:CCARrier[:IMMediate]` on page 137

EVM vs Carrier
This result display shows all EVM values recorded on a per-subcarrier basis over the number of analyzed PPDUs as defined by the "Evaluation Range > Statistics". The Tracking/Channel Estimation according to the user settings is applied (see chapter 5.3.7, "Tracking and Channel Estimation", on page 91). The Minhold, Average and Maxhold traces are displayed.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).



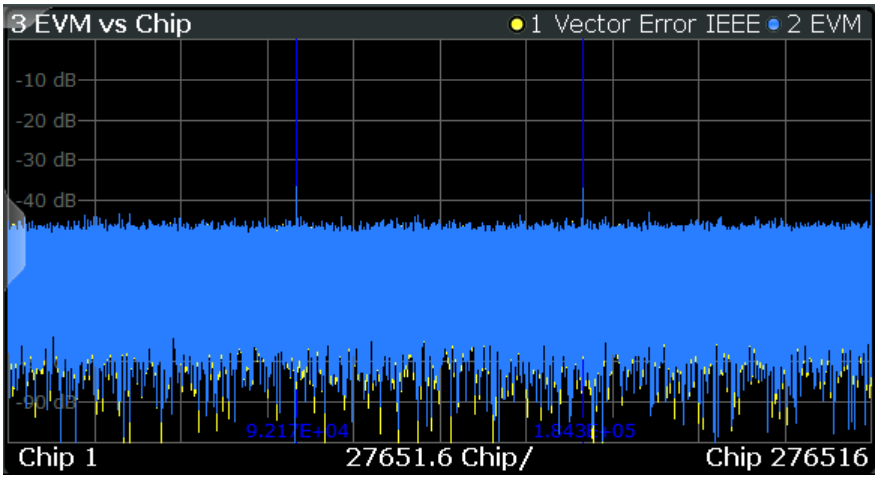
The numeric trace results for this evaluation method are described in chapter 9.9.4.5, "EVM vs Carrier", on page 218.

Remote command:
`LAY:ADD? '1',RIGH, EVC`, see `LAYout:ADD[:WINDow]?` on page 186
or:
`CONFigure:BURSt:EVM:ECARrier[:IMMediate]` on page 137

EVM vs Chip
This result display shows the error vector magnitude per chip.

This result display is **only** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

Since the R&S FSW WLAN application provides two different methods to calculate the EVM, two traces are displayed:

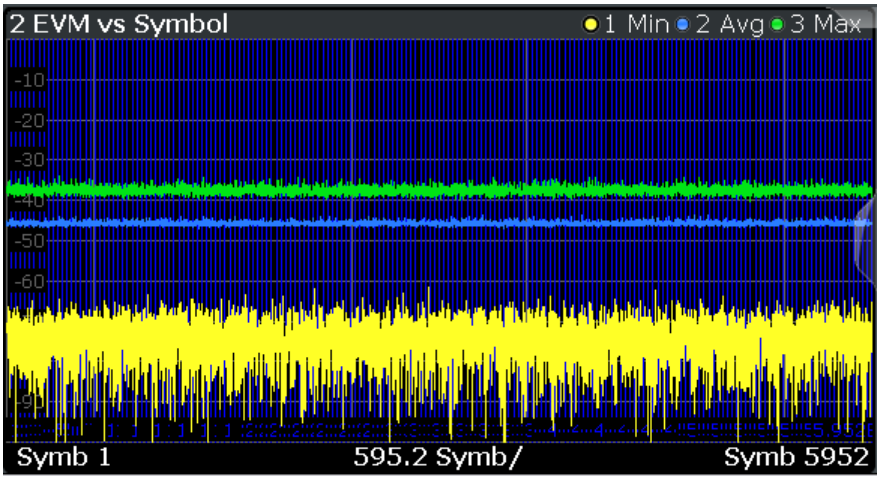


- "Vector Error IEEE" shows the error vector magnitude as defined in the IEEE 802.11b or g (DSSS) standards (see also "Error vector magnitude (EVM) - IEEE 802.11b or g (DSSS) method" on page 57)
- "EVM" shows the error vector magnitude calculated with an alternative method that provides higher accuracy of the estimations (see also "Error vector magnitude (EVM) - R&S FSW method" on page 56).

Remote command:
`LAY:ADD? '1',RIGH, EVCH`, see `LAYout:ADD[:WINDow]?` on page 186
or:
`CONFigure:BURSt:EVM:ECHip[:IMMediate]` on page 137
`CONFigure:BURSt:EVM:ESYMbol[:IMMediate]` on page 137

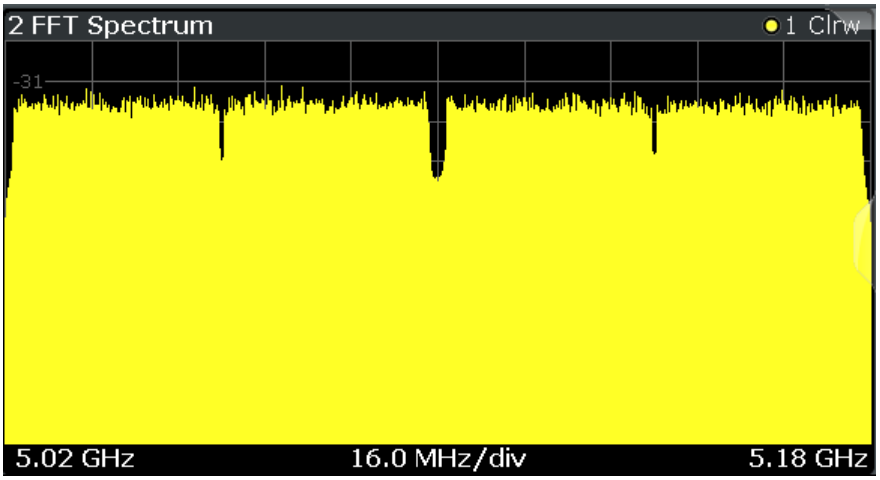
EVM vs Symbol
This result display shows all EVM values calculated on a per-carrier basis over the number of analyzed PPDUs as defined by the "Evaluation Range > Statistics" settings (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 109). The Tracking/Channel Estimation according to the user settings is applied (see chapter 5.3.7, "Tracking and Channel Estimation", on page 91). The MinHold, Maxhold, and Average traces are displayed.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).



Remote command:
`LAY:ADD? '1',RIGH, EVS`, see `LAYout:ADD[:WINDow]?` on page 186
or:
`CONFigure:BURSt:EVM:ESYMbol[:IMMediate]` on page 137

FFT Spectrum
This result display shows the power vs frequency values obtained from a FFT. The FFT is performed over the complete data in the current capture buffer, without any correction or compensation.



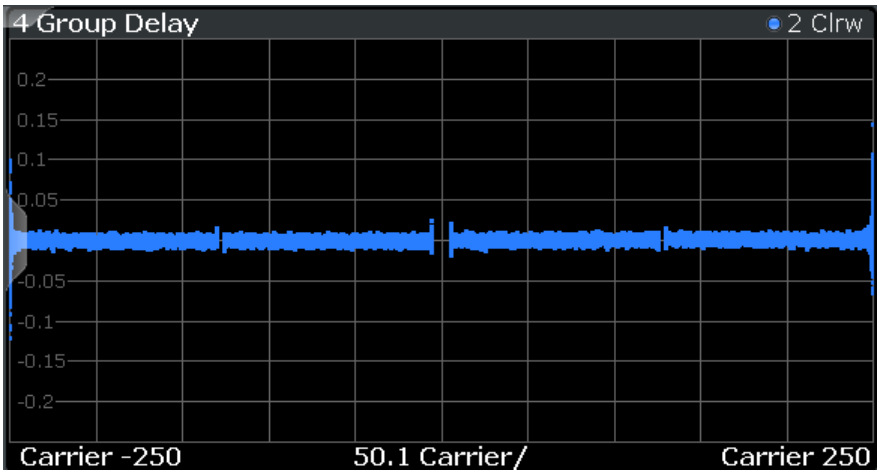
The numeric trace results for this evaluation method are described in chapter 9.9.4.6, "FFT Spectrum", on page 218.

Remote command:
`LAY:ADD? '1',RIGH, FSP`, see `LAYout:ADD[:WINDow]?` on page 186
or:
`CONFigure:BURSt:SPECtrum:FFT[:IMMediate]` on page 138

Group Delay
Displays all Group Delay (GD) values recorded on a per-subcarrier basis - over the number of analyzed PPDUs as defined by the "Evaluation Range > Statistics" settings (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 109.

All 57 carriers are shown, including the unused carrier 0.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).



Group delay is a measure of phase distortion and defined as the derivation of phase over frequency.

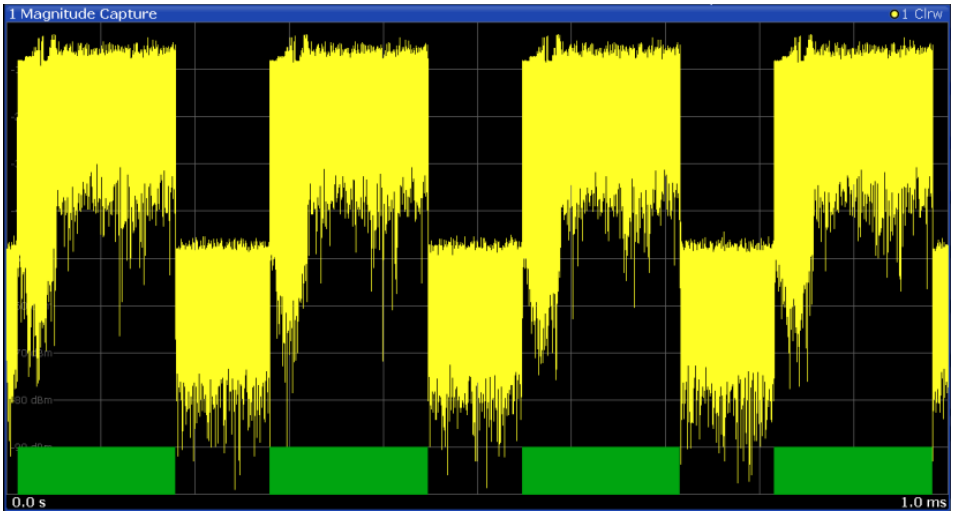
To calculate the group delay, the estimated channel is upsampled, inactive carriers are interpolated and phases are unwrapped before they are differentiated over the carrier frequencies. Thus, the group delay indicates the time a pulse in the channel is delayed for each carrier frequency. However, not the absolute delay is of interest, but rather the deviation between carriers. Thus, the mean delay over all carriers is deducted.

For an ideal channel, the phase increases linearly, which causes a constant time delay over all carriers. In this case, a horizontal line at the zero value would be the result.

The numeric trace results for this evaluation method are described in chapter 9.9.4.7, "Group Delay", on page 218.

Remote command:
`LAY:ADD? '1',RIGH, GDEL`, see `LAYout:ADD[:WINDow]?` on page 186
or:
`CONF:BURS:SPEC:FLAT:SEL GRD`, see `CONFigure:BURSt:SPECtrum:FLATness:SELect` on page 138 and
`CONFigure:BURSt:SPECtrum:FLATness[:IMMediate]` on page 138

Magnitude Capture
The Magnitude Capture Buffer display shows the complete range of captured data for the last sweep. Green bars at the bottom of the Magnitude Capture Buffer display indicate the positions of the analyzed PPDUs.



Numeric trace results are not available for this evaluation method.

Remote command:

`LAY:ADD? '1',RIGH, CMEM`, see `LAYout:ADD[:WINDow]?` on page 186

PLCP Header (IEEE 802.11b, g (GSSS)

This result display shows the decoded data from the PLCP header of the PPDU.

This result display is **only** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**); for other standards, use Signal Field instead.

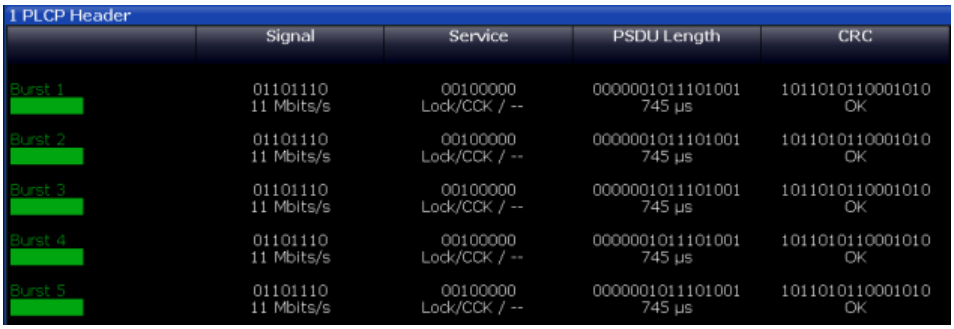


Fig. 3-9: PLCP Header result display for IEEE 802.11b, g (DSSS) standards

The following information is provided:

(The signal field information is provided as a decoded bit sequence and, where appropriate, also in human-readable form beneath the bit sequence for each PPDU.)

Table 3-4: Demodulation results in PLCP Header result display (IEEE 802.11b, g (DSSS))

Result	Description	Example
PPDU	Number of the decoded PPDU A colored block indicates that the PPDU was successfully decoded.	PPDU 1
Signal	Information in "signal" field The decoded data rate is shown below.	01101110 11 MBits/s

Result	Description	Example
Service	Information in "service" field <Symbol clock state> /<Modulation format> / <Length extension bit state> where: <Symbol clock state>: Locked / - - <Modulation format>: see table 4-1 <Length extension bit state>: 1 (set) / - - (not set)	00100000 Lock/CCK/- -
PSDU Length	Information in "length" field Time required to transmit the PSDU	0000000001111000 120 µs
CRC	Information in "CRC" field Result of cyclic redundancy code check: "OK" or "Failed"	1110100111001110 OK

Remote command:
`LAY:ADD? '1',RIGH, SFI`, see `LAYout:ADD[:WINDow]?` on page 186
or:
`CONFigure:BURSt:STATistics:SFIeld[:IMMediate]` on page 139

PvT Full PPDU
Displays the minimum, average and maximum power vs time diagram for all PPDUs.

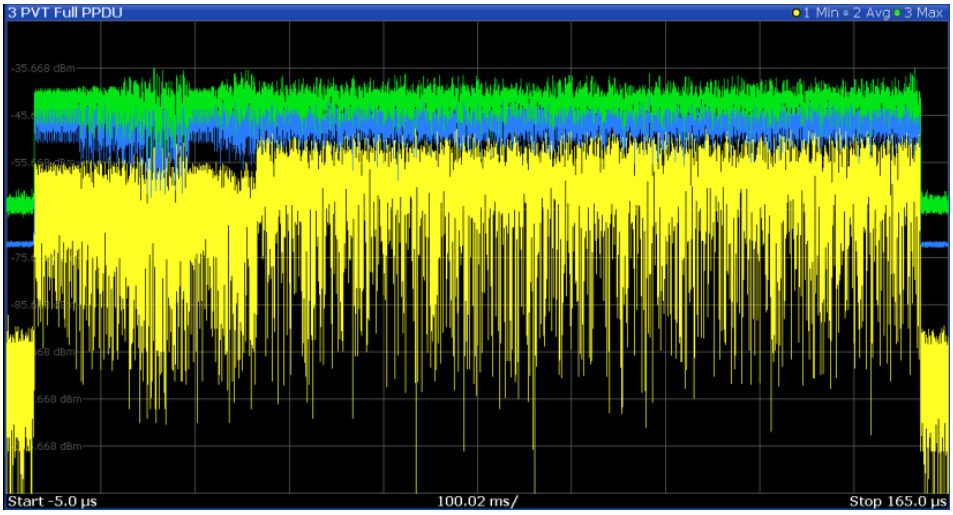


Fig. 3-10: PvT Full PPDU result display for IEEE 802.11a, g (OFDM), ac,n standards

For single-carrier measurements (**IEEE 802.11b, g (DSSS)**), the PVT results are displayed as percentage values of the reference power. The reference can be set to either the maximum or mean power of the PPDU.

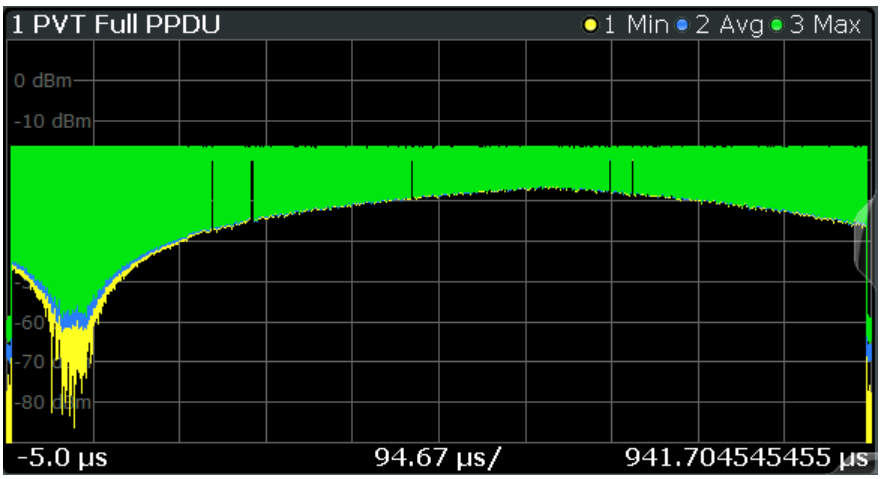


Fig. 3-11: PvT Full PPDU result display for IEEE 802.11b, g (DSSS) standards

Remote command:
`LAY:ADD:WIND '2',RIGH,PFPP` see `LAYout:ADD[:WINDow]?` on page 186

Result Summary Detailed
The *detailed* result summary contains individual measurement results for the Transmitter and Receiver channels and for the bitstream.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

3 Result Summary Detailed

TX 1

	Min	Mean	Limit	Max	Limit	Unit
IQ Offset	---	---		---		dB
Gain Imbalance	---	---		---		%
	---	---		---		dB
Quad. Offset	---	---		---		°
PPDU Power	---	---		---		dBm
Crest Factor	---	---		---		dB

RX 1

	Min	Mean	Limit	Max	Limit	Unit
PPDU Power	---	---		---		dBm
Crest Factor	---	---		---		dB

Stream 1

	Min	Mean	Limit	Max	Limit	Unit
BER Pilot	---	---		---		%
EVM All Carrier	---	---		---		dB
EVM Data Carri...	---	---		---		dB
EVM Pilot Carrier	---	---		---		dB

The "Result Summary Detailed" contains the following information:

Note: You can configure which results are displayed (see chapter 5.3.10, "Result Configuration", on page 111). However, the results are always calculated, regardless of their visibility.

Tx channel ("Tx All"):
- Quadrature offset [dB]
- Gain imbalance [%/dB]
- Quadrature offset [°]
- PPDU power [dBm]
- Crest factor [dB]

Receive channel ("Rx All"):
- PPDU power [dBm]
- Crest factor [dB]

Bitstream ("Stream All"):
- Pilot bit error rate [%]
- EVM all carriers [%/dB]
- EVM data carriers [%/dB]
- EVM pilot carriers [%/dB]

For details on the individual parameters and the summarized values see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Remote command:
`LAY:ADD? '1',RIGH, RSD`, see `LAYout:ADD[:WINDow]?` on page 186

Result Summary Global

The *global* result summary provides measurement results based on the complete signal, consisting of all channels and streams. The observation length is the number of PPDUs to be analyzed as defined by the "Evaluation Range > Statistics" settings. In contrast, the *detailed* result summary provides results for each individual channel and stream.

1 Result Summary Global

No. of PPDUs - Recognized: 19 Analyzed: 18 Analyzed Physical Channel: 18

PPDUs:	Min	Mean	Limit	Max	Limit	Unit
Pilot Bit Error Rate	0.00	0.00	0.00	0.00	0.00	%
EVM All Carriers	0.34	0.38	31.62	0.49	31.62	%
	-49.25	-48.46	-10.00	-46.15	-10.00	dB
EVM Data Carriers	0.34	0.38	31.62	0.50	31.62	%
	-49.25	-48.44	-10.00	-46.07	-10.00	dB
EVM Pilot Carriers	0.29	0.34	56.23	0.45	56.23	%
	-50.62	-49.31	-5.00	-46.99	-5.00	dB
Center Frequency Error	-4.34	-0.85	±100000.00	3.55	±100000.00	Hz
Symbol Clock Error	0.02	0.09	±20.00	0.17	±20.00	ppm

Fig. 3-12: Global result summary for IEEE 802.11a, g (OFDM) standards

1 Result Summary Global

No. of PPDUs - Recognized: 3 Analyzed: 3 Analyzed Physical Channel: 0

PPDUs:	Min	Mean	Limit	Max	Limit	Unit
Peak Vector Error	1.18	1.37	35.00	1.47	35.00	%
PPDU EVM	0.19	0.19		0.19		%
	-54.59	-54.57		-54.54		dB
IQ Offset	-67.45	-67.33		-67.24		dB
Gain Imbalance	82.34	82.34		82.34		%
	-15.06	-15.06		-15.06		dB
Quadrature Error	0.00	0.00		0.00		°
Center Freq Error	0.00	0.00	±331250.00	0.00	±331250.00	Hz
Chip Clock Error	-0.00	-0.00	±25.00	-0.00	±25.00	ppm
Rise Time	1.00	1.00	2.00	1.00	2.00	uS
Fall Time	3.18	3.18*	2.00	3.18*	2.00	uS
Mean Power	-2.62	-2.62		-2.62		dBm
Peak Power	-1.67	-1.67		-1.66		dBm
Crest Factor	0.94	0.95		0.95		dB

Fig. 3-13: Global result summary for IEEE 802.11b, g (DSSS) standards

The "Result Summary Global" contains the following information:

Note: You can configure which results are displayed (see chapter 5.3.10, "Result Configuration", on page 111). However, the results are always calculated, regardless of their visibility.

- Number of recognized PPDUs
- Number of analyzed PPDUs
- Number of analyzed PPDUs in entire physical channel (if available)

IEEE 802.11a, g (OFDM), ac, n standards:

- Pilot bit error rate [%]
- EVM all carriers [%/dB]
- EVM data carriers [%/dB]
- EVM pilot carriers [%/dB]
- Center frequency error [Hz]
- Symbol clock error [ppm]

IEEE 802.11b, g (DSSS) standards:

- Peak vector error
- PPDU EVM
- Quadrature offset
- Gain imbalance

- Quadrature error
- Center frequency error
- Chip cock error
- Rise time
- Fall time
- Mean power
- Peak power
- Crest power

For details on the individual results and the summarized values see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Remote command:
`LAY:ADD? '1',RIGH, RSG`, see `LAYout:ADD[:WINDow]?` on page 186

Signal Field
This result display shows the decoded data from the "Signal" field of each recognized PPDU. This field contains information on the modulation used for transmission.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**); use PLCP Header (IEEE 802.11b, g (GSSS) instead.

Fig. 3-14: Signal Field display for IEEE 802.11n

The signal field information is provided as a decoded bit sequence and, where appropriate, also in human-readable form, beneath the bit sequence for each PPDU.

The currently applied demodulation settings (as defined by the user, see chapter 5.3.8, "Demodulation", on page 93) are indicated beneath the table header for reference. Since the demodulation settings define which PPDUs are to be analyzed, this *logical filter* may be the reason if the "Signal Field" display is not as expected.

Table 3-5: Demodulation parameters and results for Signal Field result display (IEEE 802.11a, g (OFDM))

Parameter	Description
Format	PPDU format used for measurement (Not part of the IEEE 802.11a, g (OFDM) signal field, displayed for convenience; see "PPDU Format to measure" on page 94)
CBW	Channel bandwidth to measure (Not part of the signal field, displayed for convenience)
Rate / Mbit/s	Symbol rate per second
R	Reserved bit
Length / Sym	Human-readable length of payload in OFDM symbols

Parameter	Description
P	Parity bit
(Signal) Tail	Signal tail (preset to 0)

Table 3-6: Demodulation parameters and results for Signal Field result display (IEEE 802.11ac)

Parameter	Description
Format	PPDU format used for measurement (Not part of the IEEE 802.11ac signal field, displayed for convenience; see "PPDU Format to measure" on page 94)
MCS	Modulation and Coding Scheme (MCS) index of the PPDU as defined in IEEE Std 802.11-2012 section "20.6 Parameters for HT MCSs"
BW	Channel bandwidth to measure 0: 20 MHz 1: 40 MHz 2: 80 MHz 3: 80+80 MHz and 160MHz
L-SIG Length / Sym	Human-readable length of payload in OFDM symbols
STBC	Space-Time Block Coding 0: no spatial streams of any user has space time block coding 1: all spatial streams of all users have space time block coding
GI	Guard interval length PPDU must have to be measured 1: short guard interval is used in the Data field 0: short guard interval is not used in the Data field
Ness	Number of extension spatial streams (N_{ESS}, see "Extension Spatial Streams (sounding)" on page 107)
CRC	Cyclic redundancy code

Table 3-7: Demodulation parameters and results for Signal Field result display (IEEE 802.11n)

Parameter	Description
Format	PPDU format used for measurement (Not part of the IEEE 802.11n signal field, displayed for convenience; see "PPDU Format to measure" on page 94)
MCS	Modulation and Coding Scheme (MCS) index of the PPDU as defined in IEEE Std 802.11-2012 section "20.6 Parameters for HT MCSs"
CBW	Channel bandwidth to measure 0: 20 MHz or 40 MHz upper/lower 1: 40 MHz
HT-SIG Length / Sym	Human-readable length of payload in OFDM symbols The number of octets of data in the PSDU in the range of 0 to 65 535

Parameter	Description
SNRA	**S**moothing/**N**ot Sounding/**R**eserved/**A**ggregation: **Smoothing:** 1: channel estimate smoothing is recommended 0: only per-carrier independent (unsmoothed) channel estimate is recommended **Not Sounding:** 1: PPDU is not a sounding PPDU 0: PPDU is a sounding PPDU **Reserved:** Set to 1 **Aggregation:** 1: PPDU in the data portion of the packet contains an AMPDU 0: otherwise
STBC	Space-Time Block Coding 00: no STBC (NSTS = NSS) ≠0: the difference between the number of spacetime streams (NSTS) and the number of spatial streams (NSS) indicated by the MCS
GI	Guard interval length PPDU must have to be measured 1: short GI used after HT training 0: otherwise
Ness	Number of extension spatial streams (N_{ESS}, see "Extension Spatial Streams (sounding)" on page 107)
CRC	Cyclic redundancy code of bits 0–23 in HT-SIG1 and bits 0–9 in HT-SIG2
Tail Bits	Used to terminate the trellis of the convolution coder. Set to 0.

The values for the individual demodulation parameters are described in chapter 5.3.8, "Demodulation", on page 93. The following abbreviations are used in the "Signal Field" table:

Table 3-8: Abbreviations for demodulation parameters shown in "Signal Field" display

Abbreviation in "Signal Field" display	Parameter in "Demodulation" settings
A1st	Auto, same type as first PPDU
AI	Auto, individual for each PPDU
M<x>	Meas only the specified PPDUs (<x>)
D<x>	Demod all with specified parameter <y>

The Signal Field measurement indicates certain inconsistencies in the signal or discrepancies between the demodulation settings and the signal to be analyzed. In both cases, an appropriate warning is displayed and the results for the PPDU are highlighted orange - both in the "Signal Field" display and the "Magnitude Capture" display. If the signal was analyzed with warnings the results – indicated by a message - also contribute to the overall analysis results.

PPDUs detected in the signal that do not pass the logical filter, i.e. are not to be included in analysis, are dismissed. An appropriate message is provided. The corresponding PPDU in the capture buffer is not highlighted.

The numeric trace results for this evaluation method are described in chapter 9.9.4.9, "Signal Field", on page 219.

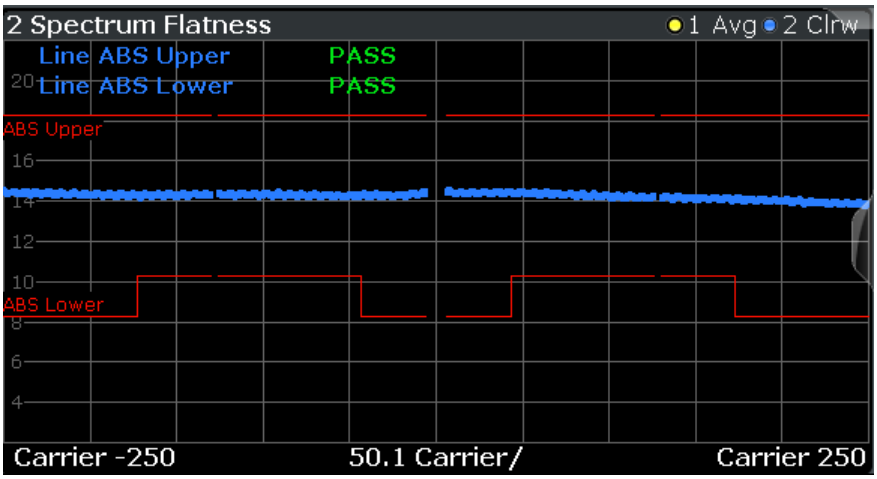
Remote command:
`LAY:ADD? '1',RIGH, SFI`, see `LAYout:ADD[:WINDow]?` on page 186
or:
`CONFigure:BURSt:STATistics:SFIeld[:IMMediate]` on page 139

Spectrum Flatness
The Spectrum Flatness trace is derived from the magnitude of the estimated channel transfer function. Since this estimated channel is calculated from all payload symbols of the PPDU, it represents a carrier-wise mean gain of the channel. Assuming that we have a cable connection between the DUT and the R&S FSW that adds no residual channel distortion, the "Spectrum Flatness" shows the spectral distortion caused by the DUT (for example the transmit filter).

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

The diagram shows the absolute power per carrier. All 57 carriers are displayed, including the unused carrier 0.

In contrast to the SISO measurements in previous R&S signal and spectrum analyzers, the trace is no longer normalized to 0 dB (scaled by the mean gain of all carriers).



The numeric trace results for this evaluation method are described in chapter 9.9.4.10, "Spectrum Flatness", on page 219.

Remote command:
`LAY:ADD? '1',RIGH, SFL`, see `LAYout:ADD[:WINDow]?` on page 186
or:
`CONF:BURS:SPEC:FLAT:SEL FLAT` (see `CONFigure:BURSt:SPECtrum:FLATness:SELect` on page 138) and
`CONFigure:BURSt:SPECtrum:FLATness[:IMMediate]` on page 138

3.2 Frequency Sweep Measurements

As described above, the WLAN IQ measurement captures the I/Q data from the WLAN signal using a (nearly rectangular) filter with a relatively large bandwidth. However, some parameters specified in the WLAN 802.11 standard require a better signal-to-noise level or a smaller bandwidth filter than the I/Q measurement provides and must be determined in separate measurements.

Parameters that are common to several digital standards and are often required in signal and spectrum test scenarios can be determined by the standard measurements provided in the R&S FSW base unit (Spectrum application). These measurements are performed using a much narrower bandwidth filter, and they capture only the power level (magnitude, which we refer to as *RF data*) of the signal, as opposed to the two components provided by I/Q data.

Frequency sweep measurements can tune on a constant frequency ("Zero span measurement") or sweep a frequency range ("Frequency sweep measurement")

The signal cannot be demodulated based on the captured RF data. However, the required power information can be determined much more precisely, as more noise is filtered out of the signal.

The Frequency sweep measurements provided by the R&S FSW WLAN application are identical to the corresponding measurements in the base unit, but are pre-configured according to the requirements of the selected WLAN 802.11 standard.

For details on these measurements see the R&S FSW User Manual.

The R&S FSW WLAN application provides the following frequency sweep measurements:

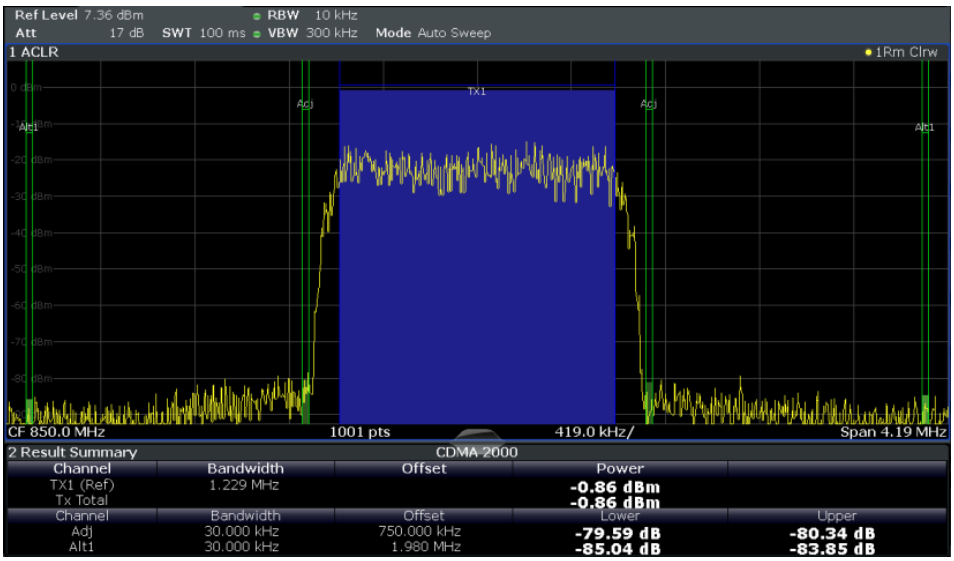
3.2.1 Measurement Types and Results for Frequency Sweep Measurements

The R&S FSW WLAN application provides the following pre-configured frequency sweep measurements:

Channel Power ACLR....39
Spectrum Emission Mask....40
Occupied Bandwidth....41
CCDF....42

Channel Power ACLR
Channel Power ACLR performs an adjacent channel power (also known as adjacent channel leakage ratio) measurement according to WLAN 802.11 specifications.

The R&S FSW measures the channel power and the relative power of the adjacent channels and of the alternate channels. The results are displayed in the Result Summary.



For details see chapter 5.4.1, "Channel Power (ACLR) Measurements", on page 115.

Remote command:

`CONFigure:BURSt:SPECtrum:ACPR[:IMMediate]` on page 140

Querying results:

`CALC:MARK:FUNC:POW:RES? ACP`, see `CALCulate:MARKer:FUNCtion:POWer:RESult?` on page 207

Spectrum Emission Mask

The Spectrum Emission Mask (SEM) measurement determines the power of the WLAN signal in defined offsets from the carrier and compares the power values with a spectral mask specified by the WLAN 802.11 specifications. The limits depend on the selected bandclass.Thus, the performance of the DUT can be tested and the emissions and their distance to the limit be identified.

Note: The WLAN 802.11 standard does not distinguish between spurious and spectral emissions.

For details see chapter 5.4.2, "Spectrum Emission Mask", on page 116.

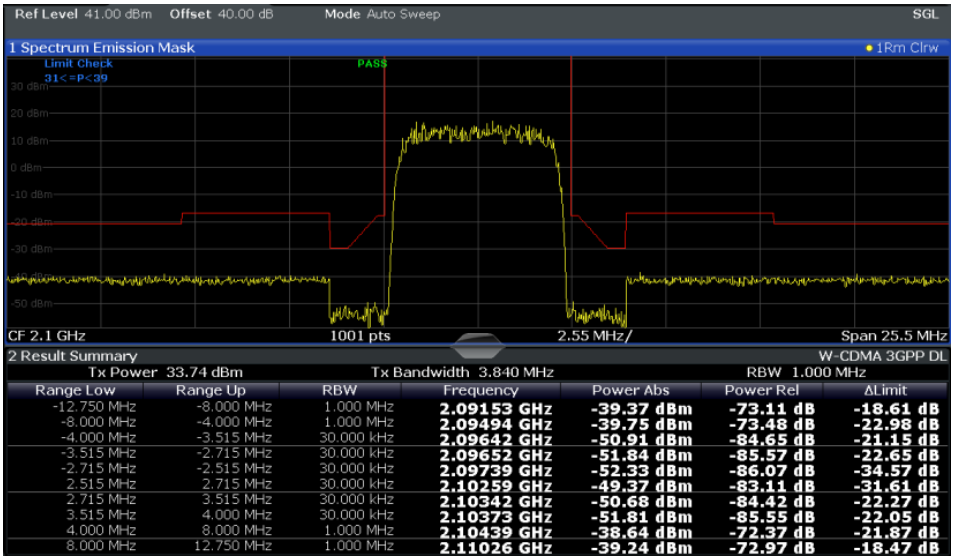

Ref Level 41.00 dBm Offset 40.00 dB Mode Auto Sweep SGL
1 Spectrum Emission Mask 1Rm Clrw
Limit Check PASS
31<=P<39
CF 2.1 GHz 1001 pts 2.55 MHz/ Span 25.5 MHz
2 Result Summary W-CDMA 3GPP DL
Tx Power 33.74 dBm Tx Bandwidth 3.840 MHz RBW 1.000 MHz
Range Low | Range Up | RBW | Frequency | Power Abs | Power Rel | ΔLimit
-12.750 MHz | -8.000 MHz | 1.000 MHz | 2.09153 GHz | -39.37 dBm | -73.11 dB | -18.61 dB
-8.000 MHz | -4.000 MHz | 1.000 MHz | 2.09494 GHz | -39.75 dBm | -73.48 dB | -22.98 dB
-4.000 MHz | -3.515 MHz | 30.000 kHz | 2.09642 GHz | -50.91 dBm | -84.65 dB | -21.15 dB
-3.515 MHz | -2.715 MHz | 30.000 kHz | 2.09652 GHz | -51.84 dBm | -85.57 dB | -22.65 dB
-2.715 MHz | -2.515 MHz | 30.000 kHz | 2.09739 GHz | -52.33 dBm | -86.07 dB | -34.57 dB
2.515 MHz | 2.715 MHz | 30.000 kHz | 2.10259 GHz | -49.37 dBm | -83.11 dB | -31.61 dB
2.715 MHz | 3.515 MHz | 30.000 kHz | 2.10342 GHz | -50.68 dBm | -84.42 dB | -22.27 dB
3.515 MHz | 4.000 MHz | 30.000 kHz | 2.10373 GHz | -51.81 dBm | -85.55 dB | -22.05 dB
4.000 MHz | 8.000 MHz | 1.000 MHz | 2.10439 GHz | -38.64 dBm | -72.37 dB | -21.87 dB
8.000 MHz | 12.750 MHz | 1.000 MHz | 2.11026 GHz | -39.24 dBm | -72.97 dB | -18.47 dB

Fig. 3-15: SEM measurement results

Remote command:

`CONFigure:BURSt:SPECtrum:MASK[:IMMediate]` on page 140

Querying results:

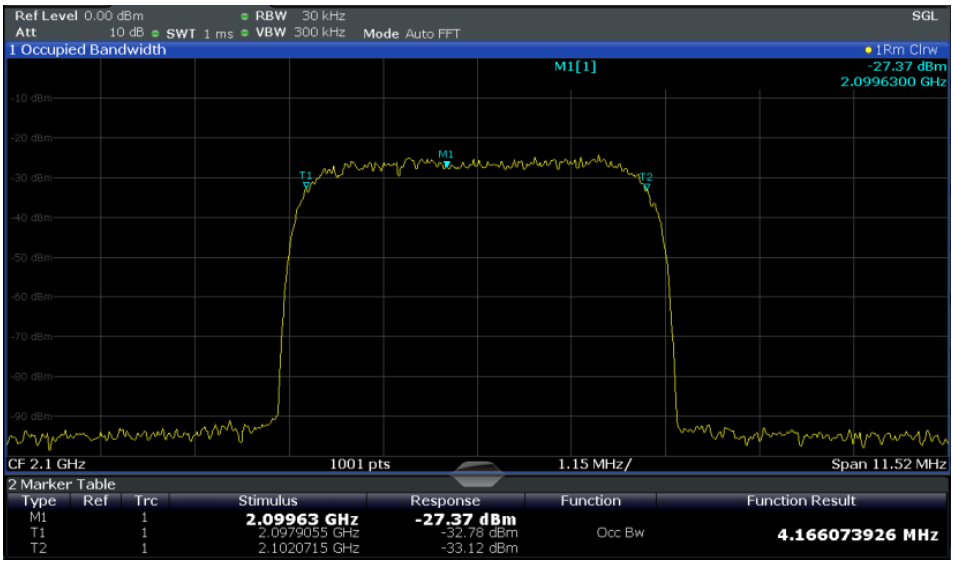
`CALCulate:LIMit<k>:FAIL` on page 207

`TRAC:DATA? LIST`, see `TRACe<n>[:DATA]` on page 210

Occupied Bandwidth

The Occupied Bandwidth (OBW) measurement determines the bandwidth in which – in default settings - 99 % of the total signal power is to be found. The percentage of the signal power to be included in the bandwidth measurement can be changed.

The occupied bandwidth is indicated as the "Occ BW" function result in the marker table; the frequency markers used to determine it are also displayed.


Ref Level 0.00 dBm RBW 30 kHz SGL
Att 10 dB SWT 1 ms VBW 300 kHz Mode Auto FFT
1 Occupied Bandwidth 1Rm Clrw
M1[1] -27.37 dBm 2.0996300 GHz
CF 2.1 GHz 1001 pts 1.15 MHz/ Span 11.52 MHz
2 Marker Table
Type | Ref | Trc | Stimulus | Response | Function | Function Result
M1 | | 1 | 2.09963 GHz | -27.37 dBm
T1 | | 1 | 2.0979055 GHz | -32.78 dBm | Occ Bw | 4.166073926 MHz
T2 | | 1 | 2.1020715 GHz | -33.12 dBm

For details see chapter 5.4.3, "Occupied Bandwidth", on page 117.

Remote command:
CONFigure:BURSt:SPECtrum:OBWidth[:IMMediate] on page 140
Querying results:
CALC:MARK:FUNC:POW:RES? OBW, see CALCulate:MARKer:FUNCtion:POWer:RESult? on page 207

CCDF
The CCDF (complementary cumulative distribution function) measurement determines the distribution of the signal amplitudes. . The measurement captures a user-definable amount of samples and calculates their mean power. As a result, the probability that a sample's power is higher than the calculated mean power + x dB is displayed. The crest factor is displayed in the Result Summary.

For details see chapter 5.4.4, "CCDF", on page 118.

Fig. 3-16: CCDF measurement results

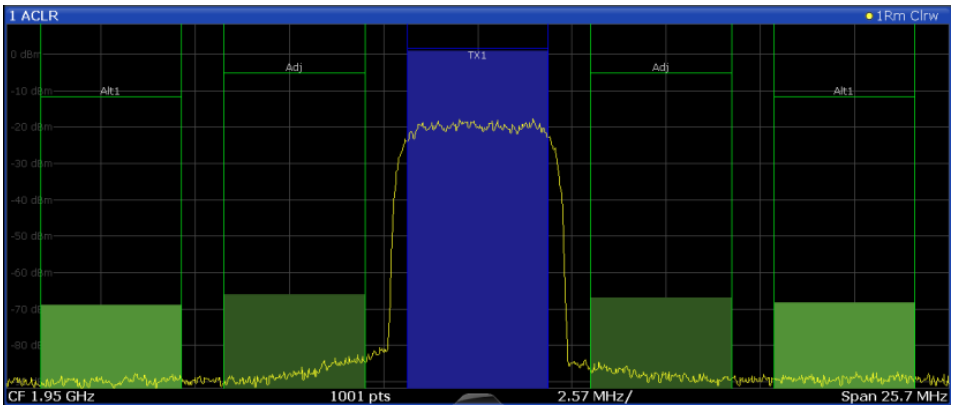
Remote command:
CONFigure:BURSt:STATistics:CCDF[:IMMediate] on page 140
Querying results:
CALCulate<n>:MARKer<m>:Y? on page 221
CALCulate:STATistics:RESult<t>? on page 209

3.2.2 Evaluation Methods for Frequency Sweep Measurements

The evaluation methods for frequency sweep measurements in the R&S FSW WLAN application are identical to those in the R&S FSW base unit (Spectrum application).

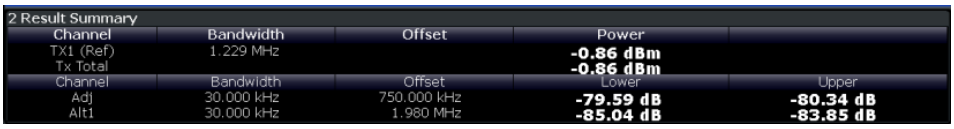
Diagram....43
Result Summary....43
Marker Table....43
Marker Peak List....44

Diagram
Displays a basic level vs. frequency or level vs. time diagram of the measured data to evaluate the results graphically. This is the default evaluation method. Which data is displayed in the diagram depends on the "Trace" settings. Scaling for the y-axis can be configured.



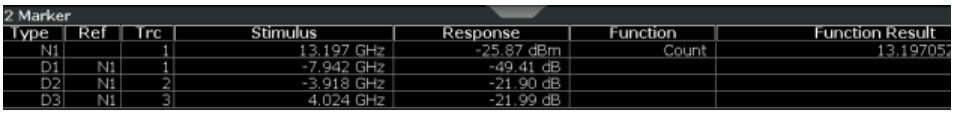
Remote command:
`LAY:ADD? '1',RIGH, DIAG`, see `LAYout:ADD[:WINDow]?` on page 186

Result Summary
Result summaries provide the results of specific measurement functions in a table for numerical evaluation. The contents of the result summary vary depending on the selected measurement function. See the description of the individual measurement functions for details.


2 Result Summary
Channel | Bandwidth | Offset | Power
TX1 (Ref) | 1.229 MHz | | -0.86 dBm
Tx Total | | | -0.86 dBm
Channel | Bandwidth | Offset | Lower | Upper
Adj | 30.000 kHz | 750.000 kHz | -79.59 dB | -80.34 dB
Alt1 | 30.000 kHz | 1.980 MHz | -85.04 dB | -83.85 dB

Remote command:
`LAY:ADD? '1',RIGH, RSUM`, see `LAYout:ADD[:WINDow]?` on page 186

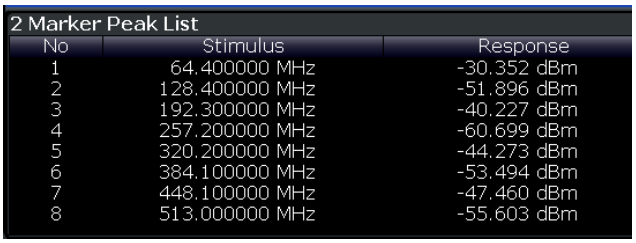
Marker Table
Displays a table with the current marker values for the active markers.


2 Marker
Type | Ref | Trc | Stimulus | Response | Function | Function Result
N1 | | 1 | 13.197 GHz | -25.87 dBm | Count | 13.19705
D1 | N1 | 1 | -7.942 GHz | -49.41 dB
D2 | N1 | 2 | -3.918 GHz | -21.90 dB
D3 | N1 | 3 | 4.024 GHz | -21.99 dB

Remote command:
`LAY:ADD? '1',RIGH, MTAB`, see `LAYout:ADD[:WINDow]?` on page 186
Results:
`CALCulate<n>:MARKer<m>:X` on page 209
`CALCulate<n>:MARKer<m>:Y?` on page 221

Marker Peak List

The marker peak list determines the frequencies and levels of peaks in the spectrum or time domain. How many peaks are displayed can be defined, as well as the sort order. In addition, the detected peaks can be indicated in the diagram. The peak list can also be exported to a file for analysis in an external application.



Remote command:

`LAY:ADD? '1',RIGH, PEAK`, see `LAYout:ADD[:WINDow]?` on page 186

Results:

`CALCulate<n>:MARKer<m>:X` on page 209

`CALCulate<n>:MARKer<m>:Y?` on page 221

4 Measurement Basics

Some background knowledge on basic terms and principles used in WLAN measurements is provided here for a better understanding of the required configuration settings.

4.1 Signal Processing for Multicarrier Measurements (IEEE 802.11a, g (OFDM))

This description gives a rough view of the signal processing when using the R&S FSW WLAN application with the IEEE 802.11a, or g (OFDM) standard. Details are disregarded in order to provide a concept overview.

Abbreviations

$a_{l,k}$	symbol at symbol l of subcarrier k
EVM_k	error vector magnitude of subcarrier k
EVM	error vector magnitude of current packet
g	signal gain
Δf	frequency deviation between Tx and Rx
l	symbol index l = {1 ... nof_Symbols}
nof_symbols	number of symbols of payload
H_k	channel transfer function of subcarrier k
k	channel index k = {–31 ... 32}
K_{mod}	modulation-dependent normalization factor
ξ	relative clock error of reference oscillator
$r_{l,k}$	subcarrier of symbol l

- Block Diagram for Multicarrier Measurements.....45
- Literature on the IEEE 802.11a Standard.....52

4.1.1 Block Diagram for Multicarrier Measurements

A diagram of the significant blocks when using the IEEE 802.11a, or g (OFDM) standard in the R&S FSW WLAN application is shown in figure 4-1.

First the RF signal is downconverted to the IF frequency f_{IF}. The resulting IF signal $r_{IF}(t)$ is shown on the left-hand side of the figure. After bandpass filtering, the signal is sampled by an analog to digital converter (ADC) at a sample rate of f_{s1}. This digital sequence is resampled. Thus, the sample rate of the downsampled sequence r(i) is the Nyquist rate of f_{s3} = 20 MHz. Up to this point the digital part is implemented in an ASIC.

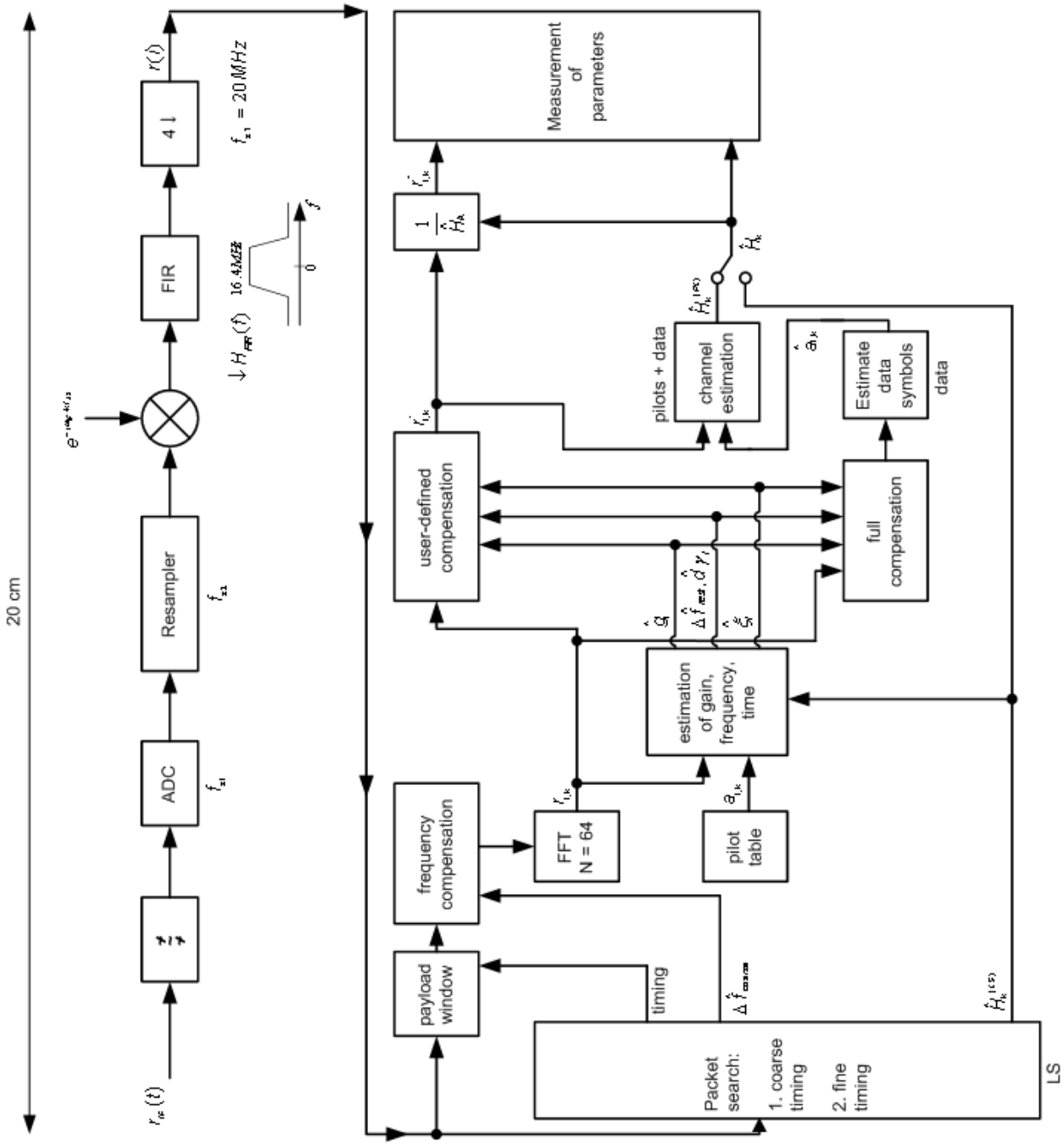


Fig. 4-1: Block diagram for the R&S FSW WLAN application using the IEEE 802.11a, or g (OFDM) standard

In the lower part of the figure the subsequent digital signal processing is shown.

Packet search and timing detection

In the first block the **packet search** is performed. This block detects the *long symbol* (LS) and recovers the timing. The **coarse timing** is detected first. This search is implemented in the time domain. The algorithm is based on cyclic repetition within the LS after N = 64 samples. Numerous treatises exist on this subject, e.g. [1] to [3].

Furthermore, a coarse estimate $\Delta\hat{f}_{coarse}$ of the Rx-Tx frequency offset Δf is derived from the metric in [6]. (The hat generally indicates an estimate, e.g. $\hat{x}$ is the estimate of x.) This can easily be understood because the phase of *r(i) ·Δ r* (i + N)* is determined by the frequency offset. As the frequency deviation Δf can exceed half a bin (distance between neighboring sub-carriers) the preceding *short symbol* (SS) is also analyzed in order to detect the ambiguity.

After the coarse timing calculation the time estimate is improved by the **fine timing** calculation. This is achieved by first estimating the coarse frequency response $\hat{H}^{(LS)}_k$, where k = {–26.. 26} denotes the channel index of the *occupied* sub-carriers. First the FFT of the LS is calculated. After the FFT calculation the known symbol information of the LS sub-carriers is removed by dividing by the symbols. The result is a coarse estimate $\hat{H}_k$ of the channel transfer function. In the next step, the complex channel impulse response is computed by an IFFT. Then the energy of the windowed impulse response (the window size is equal to the guard period) is calculated for each trial time. Afterwards the trial time of the maximum energy is detected. This trial time is used to adjust the timing.

Determing the payload window

Now the position of the LS is known and the starting point of the useful part of the first payload symbol can be derived. In the next block this calculated time instant is used to position the **payload window**. Only the payload part is windowed. This is sufficient because the payload is the only subject of the subsequent measurements.

In the next block the windowed sequence is **compensated** by the coarse frequency estimate $\Delta\hat{f}_{course}$. This is necessary because otherwise inter-channel interference (ICI) would occur in the frequency domain.

The transition to the frequency domain is achieved by an FFT of length 64. The FFT is performed symbol-wise for each symbol of the payload ("nof_symbols"). The calculated FFTs are described by$r_{l,k}$ with:

- l = {1 .. nof_symbols} as the symbol index
- k = {–31 .. 32} as the channel index

In case of an additive white Gaussian noise (AWGN) channel, the FFT is described by [4], [5]

$$r_{l,k} = K_{\mathrm{mod}} \times a_{l,k} \times g_l \times H_k \times e^{j(phase_l^{(common)} + phase_{l,k}^{(\mathrm{timing})})} + n_{l,k}$$

FFT (4 - 1)

with:

- K_{mod}: the modulation-dependant normalization factor
- $a_{l,k}$: the symbol of sub-carrier k at symbol l
- g_l: the gain at the symbol l in relation to the reference gain g = 1 at the long symbol (LS)
- H_k: the channel frequency response at the long symbol (LS)
- $phase_l^{(common)}$: the common phase drift phase of all sub-carriers at symbol l (see Common phase drift)

- $phase_{l,k}^{(timing)}$: the phase of sub-carrier k at symbol l caused by the timing drift (see Common phase drift)
- $n_{l,k}$: the independent Gaussian distributed noise samples

Phase drift and frequency deviation

The common phase drift in FFT is given by:

$$phase_l^{(common)} = 2\pi \times N_s / N \times \Delta f_{rest} T \times l + d\gamma_l$$

Common phase drift (4 - 2)

with

- N_s = 80: the number of Nyquist samples of the symbol period
- N = 64: the number of Nyquist samples of the useful part of the symbol
- Δf_{rest}: the (not yet compensated) frequency deviation
- $d\Upsilon_l$: the phase jitter at the symbol l

In general, the coarse frequency estimate $\Delta \hat{f}_{coarse}$ (see figure 4-1) is not error-free. Therefore the remaining frequency error Δf_{rest} represents the frequency deviation in $r_{l,k}$ not yet compensated. Consequently, the overall frequency deviation of the device under test (DUT) is calculated by:

$\Delta f = \Delta \hat{f}_{coarse} + \Delta f_{rest}$

The common phase drift in Common phase drift is divided into two parts to calculate the overall frequency deviation of the DUT.

The reason for the phase jitter $d\gamma_l$ in Common phase drift may be different. The nonlinear part of the phase jitter may be caused by the phase noise of the DUT oscillator. Another reason for nonlinear phase jitter may be the increase of the DUT amplifier temperature at the beginning of the PPDU. Note that besides the nonlinear part the phase jitter, $d\gamma_l$ also contains a constant part. This constant part is caused by the frequency deviation Δf_{rest} not yet compensated. To understand this, keep in mind that the measurement of the phase starts at the first symbol l = 1 of the payload. In contrast, the channel frequency response H_k in FFT represents the channel at the long symbol of the preamble. Consequently, the frequency deviation Δf_{rest} not yet compensated produces a phase drift between the long symbol and the first symbol of the payload. Therefore, this phase drift appears as a constant value ("DC value") in $d\Upsilon_l$.

Tracking the phase drift, timing jitter and gain

Referring to the IEEE 802.11a, g (OFDM) measurement standard, chapter 17.3.9.7 "Transmit modulation accuracy test" [6], the common phase drift $phase_l^{(common)}$ must be estimated and compensated from the pilots. Therefore this "symbol-wise phase tracking" is activated as the default setting of the R&S FSW WLAN application (see "Phase Tracking" on page 92).

Furthermore, the timing drift in FFT is given by:

$$phase_{l,k}^{(\mathrm{timing})} = 2\pi \times N_s / N \times \xi \times k \times l$$

Timing drift (4 - 3)

with ξ: the relative clock deviation of the reference oscillator

Normally, a symbol-wise timing jitter is negligible and thus not modeled in Timing drift. However, there may be situations where the timing drift has to be taken into account. This is illustrated by an example: In accordance to [6], the allowed clock deviation of the DUT is up to ξ_{max} = 20 ppm. Furthermore, a long packet with 400 symbols is assumed. The result of FFT and Timing drift is that the phase drift of the highest sub-carrier k = 26 in the last symbol l = **nof_symbols** is 93 degrees. Even in the noise-free case, this would lead to symbol errors. The example shows that it is actually necessary to estimate and compensate the clock deviation, which is accomplished in the next block.

Referring to the IEEE 802.11a, g (OFDM) measurement standard [6], the timing drift $phase_{l,k}^{(timing)}$ is not part of the requirements. Therefore the "time tracking" is not activated as the default setting of the R&S FSW WLAN application (see "Timing Error Tracking" on page 92). The time tracking option should rather be seen as a powerful analyzing option.

In addition, the tracking of the gain g_l in FFT is supported for each symbol in relation to the reference gain g = 1 at the time instant of the long symbol (LS). At this time the coarse channel transfer function $\hat{H}^{(LS)}_k$ is calculated.

This makes sense since the sequence $r'_{l,k}$ is compensated by the coarse channel transfer function $\hat{H}^{(LS)}_k$ before estimating the symbols. Consequently, a potential change of the gain at the symbol l (caused, for example, by the increase of the DUT amplifier temperature) may lead to symbol errors especially for a large symbol alphabet M of the MQAM transmission. In this case, the estimation and the subsequent compensation of the gain are useful.

Referring to the IEEE 802.11a, g (OFDM) measurement standard [6], the compensation of the gain g_l is not part of the requirements. Therefore the "gain tracking" is not activated as the default setting of the R&S FSW WLAN application (see ."Level Error (Gain) Tracking" on page 93).

Determining the error parameters (log likelihood function)

How can the parameters above be calculated? In this application the optimum maximum likelihood algorithm is used. In the first estimation step the symbol-independent parameters Δ f_{rest} and ξ are estimated. The symbol dependent parameters can be neglected in this step, i.e. the parameters are set to g_l = 1 and dγ = 0. Referring to FFT, the log likelihood function L must be calculated as a function of the trial parameters $\Delta\tilde{f}_{rest}$ and $\tilde{\xi}$. (The tilde generally describes a trial parameter. Example: $\tilde{x}$ is the trial parameter of x.)

$$L_1(\Delta\tilde{f}_{rest},\tilde{\xi}) = \sum_{l=1}^{nof\_symbols} \sum_{k=-21,-7,7,21} \left| r_{l,k} - a_{l,k} \times \hat{H}_k^{(LS)} \times e^{j(\tilde{p}hase_l^{(common)} + \tilde{p}hase_{l,k}^{(ti\min g)})} \right|^2$$

with

$$\tilde{p}hase_l^{(common)} = 2\pi \times N_s / N \times \Delta\tilde{f}_{rest} T \times l$$

$$\tilde{p}hase_l^{(ti\min g)} = 2\pi \times N_s / N \times \tilde{\xi} \times k \times l$$

Log likelihood function (step 1) (4 - 4)

The trial parameters leading to the minimum of the log likelihood function are used as estimates $\Delta\hat{f}_{rest}$ and $\hat{\xi}$. In Log likelihood function (step 1) the known pilot symbols $a_{l,k}$ are read from a table.

In the second step, the log likelihood function is calculated for every symbol l as a function of the trial parameters $\tilde{g}_l$ and $d\tilde{\gamma}_l$:

$$L_2(\tilde{g}_l, d\tilde{\gamma}_l) = \sum_{k=-21,-7,7,21} \left| r_{l,k} - a_{l,k} \times \tilde{g}_l \times \hat{H}_k^{(LS)} \times e^{j(\tilde{p}hase_l^{(common)} + \tilde{p}hase_{l,k}^{(ti\min g)})} \right|^2$$

with

$$\tilde{p}hase_l^{(common)} = 2\pi \times N_s / N \times \Delta\hat{f}_{rest} T \times l + d\tilde{\gamma}_l$$

$$\hat{p}hase_l^{(ti\min g)} = 2\pi \times N_s / N \times \hat{\xi} \times k \times l$$

Log likelihood function (step 2) (4 - 5)

Finally, the trial parameters leading to the minimum of the log likelihood function are used as estimates $\hat{g}_l$ and $\hat{d\tilde{\gamma}}_l$.

This robust algorithm works well even at low signal to noise ratios with the Cramer Rao Bound being reached.

Compensation

After estimation of the parameters, the sequence $r_{l,k}$ is compensated in the compensation blocks.

In the upper analyzing branch the compensation is user-defined i.e. the user determines which of the parameters are compensated. This is useful in order to extract the influence of these parameters. The resulting output sequence is described by: $\gamma'_{\delta,k}$.

Data symbol estimation

In the lower compensation branch the full compensation is always performed. This separate compensation is necessary in order to avoid symbol errors. After the full compensation the secure estimation of the data symbols $\hat{a}_{l,k}$ is performed. From FFT it is clear that first the channel transfer function H_k must be removed. This is achieved by dividing the known coarse channel estimate $\hat{H}^{(LS)}_k$ calculated from the LS. Usually an error free estimation of the data symbols can be assumed.

Improving the channel estimation

In the next block a better channel estimate $\hat{H}^{(PL)}_k$ of the data and pilot sub-carriers is calculated by using all "nof_symbols" symbols of the payload (PL). This can be accomplished at this point because the phase is compensated and the data symbols are known. The long observation interval of nof_symbols symbols (compared to the short interval of 2 symbols for the estimation of $\hat{H}^{(LS)}_k$) leads to a nearly error-free channel estimate.

In the following equalizer block, $\hat{H}^{(LS)}_k$ is compensated by the channel estimate. The resulting channel-compensated sequence is described by $\gamma_{\delta,k}''$. The user may either choose the coarse channel estimate $\hat{H}^{(LS)}_k$ (from the long symbol) or the nearly error-free channel estimate $\hat{H}^{(PL)}_k$ (from the payload) for equalization. If the improved estimate $\hat{H}^{(LS)}_k$ is used, a 2 dB reduction of the subsequent EVM measurement can be expected.

According to the IEEE 802.11a measurement standard [6], the coarse channel estimation $\hat{H}^{(LS)}_k$ (from the long symbol) has to be used for equalization. Therefore the default setting of the R&S FSW WLAN application is equalization from the coarse channel estimate derived from the long symbol.

Calculating error parameters

In the last block the parameters of the demodulated signal are calculated. The most important parameter is the error vector magnitude of the sub-carrier "k" of the current packet:

$$\overline{EVM} = \sqrt{\frac{1}{nof\_packets} \sum_{counter=1}^{nof\_packets} EVM^2(counter)}$$

Error vector magnitude of the subcarrier k in current packet (4 - 6)

Furthermore, the packet error vector magnitude is derived by averaging the squared EVM_k versus k:

$$EVM = \sqrt{\frac{1}{52} \sum_{k=-26(k\neq 0)}^{26} EVM_k^2}$$

Error vector magnitude of the entire packet (4 - 7)

Finally, the average error vector magnitude is calculated by averaging the packet EVM of all nof_symbols detected packets:

$$EVM_k = \sqrt{\frac{1}{nof\_symbols} \sum_{l=1}^{nof\_symbols} \left| r_{l,k}'' - K_{\mathrm{mod}} \times a_{l,k} \right|^2}$$

Average error vector magnitude (4 - 8)

This parameter is equivalent to the "RMS average of all errors": $Error_{RMS}$ of the IEEE 802.11a measurement commandment (see [6]).

4.1.2 Literature on the IEEE 802.11a Standard

[1]	Speth, Classen, Meyr: "Frame synchronization of OFDM systems in frequency selective fading channels", VTC '97, pp. 1807-1811
[2]	Schmidl, Cox: "Robust Frequency and Timing Synchronization of OFDM", IEEE Trans. on Comm., Dec. 1997, pp. 1613-621
[3]	Minn, Zeng, Bhargava: "On Timing Offset Estimation for OFDM", IEEE Communication Letters, July 2000, pp. 242-244
[4]	Speth, Fechtel, Fock, Meyr: "Optimum Receiver Design for Wireless Broad-Band Systems Using OFDM – Part I", IEEE Trans. On Comm. VOL. 47, NO 11, Nov. 1999
[5]	Speth, Fechtel, Fock, Meyr: "Optimum Receiver Design for Wireless Broad-Band Systems Using OFDM – Part II", IEEE Trans. On Comm. VOL. 49, NO 4, April. 2001
[6]	IEEE 802.11a, Part 11: WLAN Medium Access Control (MAC) and Physical Layer (PHY) specifications

4.2 Signal Processing for Single-Carrier Measurements (IEEE 802.11b, g (DSSS))

This description gives a rough overview of the signal processing concept of the WLAN 802.11 application for IEEE 802.11b or g (DSSS) signals.

Abbreviations

ε	timing offset
Δ"f"	frequency offset
$\Delta\Phi$	phase offset
$\hat{g}_I$	estimate of the gain factor in the I-branch
$\hat{g}_Q$	estimate of the gain factor in the Q-branch
$\Delta\hat{g}_Q$	accurate estimate of the crosstalk factor of the Q-branch in the I-branch
$\hat{h}_s(v)$	estimated baseband filter of the transmitter
$\hat{h}_r(v)$	estimated baseband filter of the receiver
$\hat{o}_I$	estimate of the IQ-offset in the I-branch
$\hat{o}_Q$	estimate of the IQ-offset in the I-branch
r(v)	measurement signal
$\hat{s}(v)$	estimate of the reference signal
$\hat{s}_n(v)$	estimate of the power-normalized and undisturbed reference signal
ARG{...}	calculation of the angle of a complex value
EVM	error vector magnitude

IMAG{...}	calculation of the imaginary part of a complex value
PPDU	protocol data unit - a burst in the signal containing transmission data
PSDU	protocol service data unit- a burst in the signal containing service data
REAL{...}	calculation of the real part of a complex value

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- Calculation of Signal Parameters.....55
- Literature on the IEEE 802.11b Standard.....58

4.2.1 Block Diagram for Single-Carrier Measurements

A block diagram of the measurement application is shown below in figure 4-2. The baseband signal of an IEEE 802.11b or g (DSSS) wireless LAN system transmitter is sampled with a sample rate of 44 MHz.

The first task of the measurement application is to detect the position of the PPDU within the measurement signal $r_1(v)$. The detection algorithm is able to find the the beginning of short and long PPDUs and can distinguish between them. The algorithm also detects the initial state of the scrambler, which is not specified by the IEEE 802.11 standard.

If the start position of the PPDU is known, the header of the PPDU can be demodulated. The bits transmitted in the header provide information about the length of the PPDU and the modulation type used in the PSDU.

Once the start position and the PPDU length are fully known, better estimates of timing offset, timing drift, frequency offset and phase offset can be calculated using the entire data of the PPDU.

At this point of the signal processing, demodulation can be performed without decision error. After demodulation the normalized (in terms of power) and undisturbed reference signal s(v) is available.

If the frequency offset is not constant and varies with time, the frequency offset and phase offset in several partitions of the PPDU must be estimated and corrected. Additionally, timing offset, timing drift and gain factor can be estimated and corrected in several partitions of the PPDU. These corrections can be switched off individually in the demodulation settings of the application.

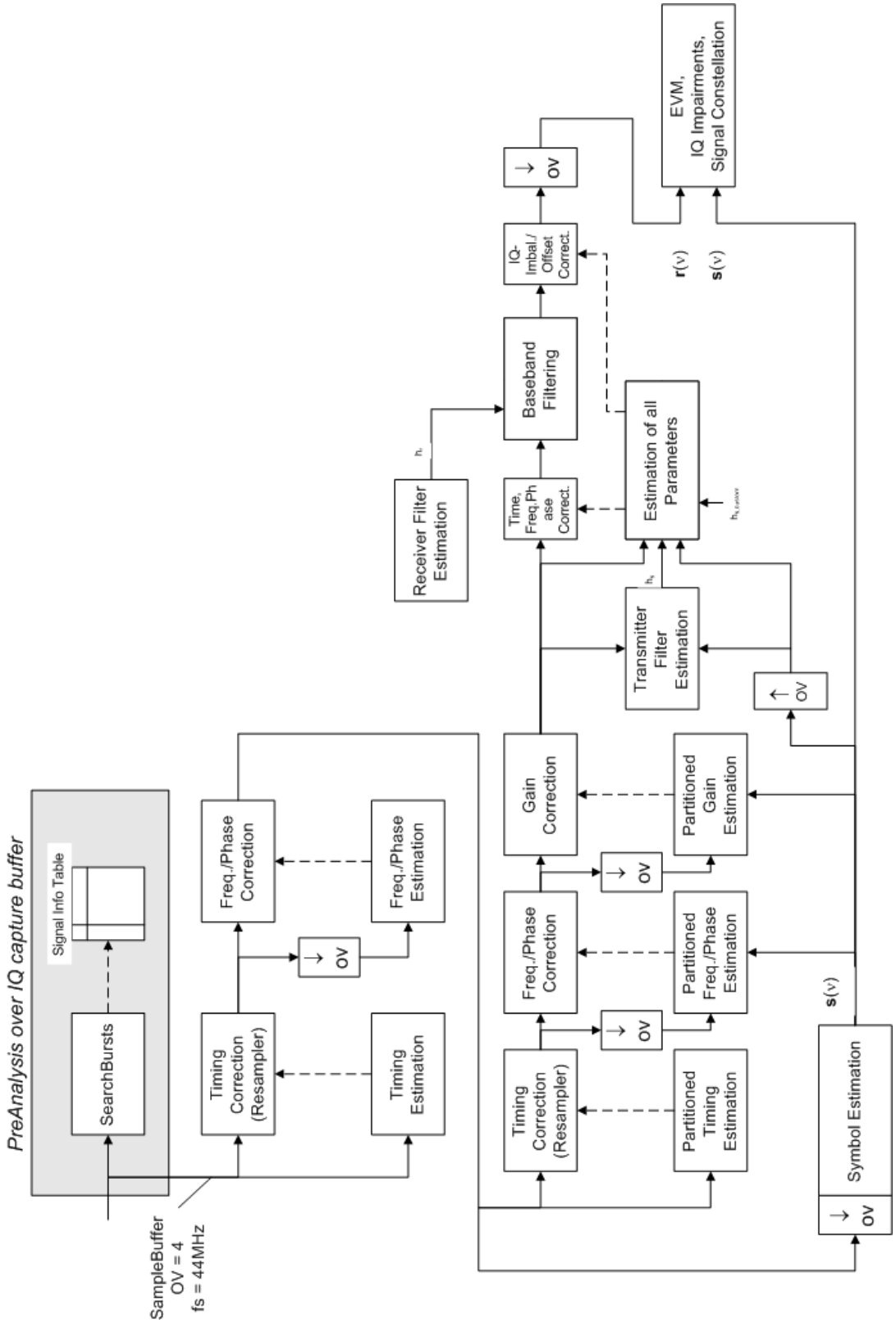


Fig. 4-2: Signal processing for IEEE 802.11b or g (DSSS) signals

Once the the normalized and undisturbed reference signal is available, the transmitter baseband filter (Tx filter) is estimated by minimizing the cost function of a maximum-likelihood-based estimator:

$$L_1 = \sum_{\nu=0}^{N-1} \left| r(\nu) \times e^{-j2\pi\Delta\tilde{f}\nu} \times e^{-j\Delta\tilde{\phi}} - \sum_{i=-L}^{+L} \tilde{h}_s(i) \times \hat{s}_n(\nu - i) - \tilde{o}_I - j\tilde{o}_Q \right|^2$$

Transmitter baseband filter (Tx filter) estimation (4 - 9)

where:

$r(\nu)$: the oversampled measurement signal

$\hat{s}_n(\nu)$: the normalized oversampled power of the undisturbed reference signal

N : the observation length

L : the filter length

$\Delta\tilde{f}\nu$: the variation parameters of the frequency offset

$\Delta\tilde{\phi}$: the variation parameters of the phase offset

$\tilde{o}_I$ $\tilde{o}_Q$: the variation parameters of the IQ-offset

$\tilde{h}_s(i)$: the coefficients of the transmitter filter

4.2.2 Calculation of Signal Parameters

The frequency offset, the phase offset and the IQ-offset are estimated jointly with the coefficients of the transmit filter to increase the estimation quality.

Once the transmit filter is known, all other unknown signal parameters are estimated with a maximum-likelihood-based estimation, which minimizes the cost function:

$$L_2 = \sum_{\nu=0}^{N-1} \left| r(\nu - \tilde{\varepsilon}) \times e^{-j2\pi\tilde{f}\nu} \times e^{-j\Delta\tilde{\phi}} - \tilde{g}_I \times s_I(\nu) - j\tilde{g}_Q \times s_Q(\nu) + \Delta\tilde{g}_Q \times s_Q(\nu) - \tilde{o}_I - j\tilde{o}_Q \right|^2$$

Cost function for signal parameters (4 - 10)

where:

$\tilde{g}_I$ $\tilde{g}_Q$: the variation parameters of the gain used in the I/Q-branch

$\Delta\tilde{g}_Q$: the crosstalk factor of the Q-branch into the I-branch

$s_I(\nu)$ $s_Q(\nu)$: the filtered reference signal of the I/Q-branch

The unknown signal parameters are estimated in a joint estimation process to increase the accuracy of the estimates.

The accurate estimates of the frequency offset, the gain imbalance, the quadrature error and the normalized I/Q offset are displayed by the measurement software.

Gain imbalance, I/Q offset, quadrature error

The gain imbalance is the quotient of the estimates of the gain factor of the Q-branch, the crosstalk factor and the gain factor of the I-branch:

$$Gain - imbalance = \left| \frac{\hat{g}_Q + \Delta\hat{g}_Q}{\hat{g}_I} \right|$$

Gain imbalance (4 - 11)

The quadrature error is a measure for the crosstalk of the Q-branch into the I-branch:

$$Quadrature - Error = ARG\left\{\hat{g}_Q + j \times \Delta\hat{g}_Q\right\}$$

Quadrature error (crosstalk) (4 - 12)

The normalized I/Q offset is defined as the magnitude of the I/Q offset normalized by the magnitude of the reference signal:

$$IQ - Offset = \frac{\sqrt{\hat{o}_I^2 + \hat{o}_Q^2}}{\sqrt{\frac{1}{2} \cdot \left[\hat{g}_I^2 + \hat{g}_Q^2\right]^2}}$$

I/Q offset (4 - 13)

At this point of the signal processing all unknown signal parameters such as timing offset, frequency offset, phase offset, I/Q offset and gain imbalance have been evaluated and the measurement signal can be corrected accordingly.

Error vector magnitude (EVM) - R&S FSW method

Using the corrected measurement signal r(v) and the estimated reference signal □(v), the modulation quality parameters can be calculated. The mean error vector magnitude (EVM) is the quotient of the root-mean-square values of the error signal power and the reference signal power:

$$EVM = \frac{\sqrt{\sum_{v=0}^{N-1} \left| r(v) - \hat{s}(v) \right|^2}}{\sqrt{\sum_{v=0}^{N-1} \left| \hat{s}(v) \right|^2}}$$

Mean error vector magnitude (EVM) (4 - 14)

Whereas the symbol error vector magnitude is the momentary error signal magnitude normalized by the root mean square value of the reference signal power:

$$EVM(v) = \frac{|r(v) - \hat{s}(v)|}{\sqrt{\sum_{v=0}^{N-1} |\hat{s}(v)|^2}}$$

Symbol error vector magnitude (4 - 15)

Error vector magnitude (EVM) - IEEE 802.11b or g (DSSS) method

In [2] a different algorithm is proposed to calculate the error vector magnitude. In a first step the IQ-offset in the I-branch and the IQ-offset of the Q-branch are estimated separately:

$$\hat{o}_I = \frac{1}{N} \sum_{v=0}^{N-1} \mathrm{REAL}\{r(v)\}$$

I/Q offset I-branch (4 - 16)

$$\hat{o}_Q = \frac{1}{N} \sum_{v=0}^{N-1} \mathrm{IMAG}\{r(v)\}$$

I/Q offset Q-branch (4 - 17)

where r(v) is the measurement signal which has been corrected with the estimates of the timing offset, frequency offset and phase offset, but not with the estimates of the gain imbalance and I/Q offset

With these values the gain imbalance of the I-branch and the gain imbalance of the Q-branch are estimated in a non-linear estimation in a second step:

$$\hat{g}_I = \frac{1}{N} \sum_{v=0}^{N-1} \left| \mathrm{REAL}\{r(v) - \hat{o}_I\} \right|$$

Gain imbalance I-branch (4 - 18)

$$\hat{g}_Q = \frac{1}{N} \sum_{v=0}^{N-1} \left| \mathrm{IMAG}\{r(v) - \hat{o}_Q\} \right|$$

Gain imbalance Q-branch (4 - 19)

Finally, the mean error vector magnitude can be calculated with a non-data-aided calculation:

$$V_{\mathrm{err}}(v) = \frac{\sqrt{\frac{1}{2} \sum_{v=0}^{N-1} \left[\left| \mathrm{REAL}\{r(v)\} - \hat{o}_I \right| - \hat{g}_I \right]^2 + \frac{1}{2} \sum_{v=0}^{N-1} \left[\left| \mathrm{IMAG}\{r(v)\} - \hat{o}_Q \right| - \hat{g}_Q \right]^2}}{\sqrt{\frac{1}{2} \cdot \left[\hat{g}_I^2 + \hat{g}_Q^2 \right]}}$$

Mean error vector magnitude (4 - 20)

The symbol error vector magnitude is the error signal magnitude normalized by the root mean square value of the estimate of the measurement signal power:

$$V_{err}(v) = \frac{\sqrt{\frac{1}{2}\left[\text{REAL}\{r(v)\} - \hat{o}_I\right| - \hat{g}_I\left.\right]^2 + \frac{1}{2}\left[\text{IMAG}\{r(v)\} - \hat{o}_Q\right| - \hat{g}_Q\left.\right]^2}}{\sqrt{\frac{1}{2}\cdot\left[\hat{g}_I^2 + \hat{g}_Q^2\right]^2}}$$

Symbol error vector magnitude (4 - 21)

The advantage of this method is that no estimate of the reference signal is needed, but the I/Q offset and gain imbalance values are not estimated in a joint estimation procedure. Therefore, each estimation parameter disturbs the estimation of the other parameter and the accuracy of the estimates is lower than the accuracy of the estimations achieved by Transmitter baseband filter (Tx filter) estimation. If the EVM value is dominated by Gaussian noise this method yields similar results as Cost function for signal parameters.

The EVM vs Symbol result display shows two traces, each using a different calculation method, so you can easily compare the results (see "EVM vs Symbol" on page 27).

4.2.3 Literature on the IEEE 802.11b Standard

[1]	Institute of Electrical and Electronic Engineers, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications, IEEE Std 802.11-1999, Institute of Electrical and Electronic Engineers, Inc., 1999.
[2]	Institute of Electrical and Electronic Engineers, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher-Speed Physical Layer Extensions in the 2.4 GHz Band, IEEE Std 802.11b-1999, Institute of Electrical and Electronic Engineers, Inc., 1999.

4.3 Physical vs Effective Channels

The data transmitted between a sender and the recipient is referred to as a *space-time stream*. Space-time streams contain the coded data that is to be transmitted. (The transmitted, demodulated and decoded data is referred to as a *bitstream*.) In order to transmit the data, one or more antennas are required by the sender, and one or more antennas are required by the receiver.

For each space-time stream, at least one training field is included in every PPDU preamble. Each sender antenna transmits these known training fields. The space-time streams are then mapped to the receiver antennas. The mapping of a space-time stream to a receiver antenna is also referred to as an *effective channel*.

If the spatial mapping is known and the channel matrix is invertible, the mapping of the receiver antenna to the sender antenna for a space-time stream can be determined. This mapping is referred to as a *physical channel*.

While the physical channels cannot always be determined, the effective channel can always be estimated from the known training fields. Thus, for some PPDUs or measure-

ment scenarios, only the results based on the mapping of the space-time stream to the Rx antenna (effective channel) are available, as the mapping of the Rx antennas to the Tx antennas (physical channel) could not be determined.

If the physical channels can be determined, the R&S FSW WLAN application can provide spectral results (channel flatness, group delay, channel phase, channel impulse response and channel singular values) for the physical (Tx and Receiver) channels and the effective channel (stream).

Channels and carriers

In an OFDM system such as WLAN, the channel is divided into carriers using FFT / IFFT. Depending on the channel bandwidth, the FFT window varies between 64 and 512 (see also chapter 4.5, "Demodulation Parameters - Logical Filters", on page 60). Some of these carriers can be used (active carriers), others are inactive (e.g. guard carriers at the edges). The channel can then be determined using the active carriers as known points; inactive carriers are interpolated.

Channel Display in the Spectrum Analyzer

In the R&S FSW WLAN application, channels are represented by their transmission spectrum, i.e. the gains of the active carriers. In effect, a *physical channel* represents the transmission spectrum sent by a particular sender and received by a particular receiver antenna. An *effective* channel, on the other hand, represents the transmission spectrum of a specific space-time stream received by a particular receiver antenna.

4.4 Recognized vs. Analyzed PPDUs

A PPDU in a WLAN signal consists of the following parts:

- **Preamble**
  Information required to recognize the PPDU within the signal
- **Signal Field**
  Information on the modulation used for transmission of the useful data
- **Payload**
  The useful data

During signal processing, PPDUs are recognized by their preamble symbols. The recognized PPDUs and the information on the modulation used for transmission of the useful data are shown in the "Signal Field" result display (see "Signal Field" on page 35).

Not all of the recognized PPDUs must be analyzed. Some are dismissed because the PPDU parameters do not match the user-defined demodulation settings, which act as a *logical filter* (see also chapter 4.5, "Demodulation Parameters - Logical Filters", on page 60). Others may be dismissed because they contain too many or too few payload symbols (as defined by the standard), or due to other irregularities or inconsistency. Dismissed PPDUs are indicated as such in the "Signal Field" result display. Only the remaining, *valid* PPDUs are actually analyzed. The PPDUs to be analyzed are highlighted in the "Magnitude Capture" buffer display.

Then again, the *physical channel* cannot always be determined for all analyzed PPDUs. In this case, results are only available for the *effective channel* (see also chapter 4.3, "Physical vs Effective Channels", on page 58).

4.5 Demodulation Parameters - Logical Filters

The demodulation settings define which PPDUs are to be analyzed, thus they define a *logical filter*. They can either be defined using specific values or according to the first measured PPDU.

Which of the WLAN demodulation parameter values are supported depends on the selected digital standard, some are also interdependant.

Table 4-1: Supported modulation formats, PPDU formats and channel bandwidths depending on standard

Standard	Modulation formats	PPDU formats	Channel bandwidths
IEEE 802.11a, g (OFDM)	BPSK (6 Mbps & 9 Mbps) QPSK (12 Mbps & 18 Mbps) 16QAM (24 Mbps & 36 Mbps) 64QAM (48 Mbps & 54 Mbps)	HT	5 MHz, 10 MHz, 20 MHz*)
IEEE 802.11ac	16QAM 64QAM 256QAM	VHT	20 MHz*), 40 MHz*), 80 MHz*), 160 MHz*)
IEEE 802.11b, g (DSSS)	DBPSK (1 Mbps) DQPSK (2 Mbps) CCK (5.5 Mbps & 11 Mbps) PBCC (5.5 Mbps & 11 Mbps)	Short PPDU Long PPDU	22 MHz
IEEE 802.11n	**SISO:** BPSK (6.5, 7.2, 13.5 & 15 Mbps) QPSK (13, 14.4, 19.5, 21.7, 27, 30, 40,5 & 45 Mbps) 16QAM (26, 28.9, 39, 43.3, 54, 60, 81 & 90 Mbps) 64QAM (52, 57.8, 58.5, 65, 72.2, 108, 121.5, 135, 120, 135 & 150 Mbps) **MIMO:** depends on the MCS index	HT-MF (Mixed format) HT-GF (Greenfield format)	20 MHz*), 40 MHz*)
*): requires R&S FSW bandwidth extension option, see chapter A.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 230			

4.6 Receiving Data Input and Providing Data Output

The R&S FSW can analyze signals from different input sources and provide various types of output (such as noise or trigger signals).

4.6.1 RF Input Protection

The RF input connector of the R&S FSW must be protected against signal levels that exceed the ranges specified in the data sheet. Therefore, the R&S FSW is equipped with an overload protection mechanism. This mechanism becomes active as soon as the power at the input mixer exceeds the specified limit. It ensures that the connection between RF input and input mixer is cut off.

When the overload protection is activated, an error message is displayed in the status bar ("INPUT OVLD"), and a message box informs you that the RF Input was disconnected. Furthermore, a status bit (bit 3) in the `STAT:QUES:POW` status register is set. In this case you must decrease the level at the RF input connector and then close the message box. Then measurement is possible again. Reactivating the RF input is also possible via the remote command `INPut:ATTenuation:PROTection:RESet` .

4.6.2 Input from Noise Sources

The R&S FSW provides a connector (NOISE SOURCE CONTROL) with a voltage supply for an external noise source. By switching the supply voltage for an external noise source on or off in the firmware, you can activate or deactive the device as required.

External noise sources are useful when you are measuring power levels that fall below the noise floor of the R&S FSW itself, for example when measuring the noise level of an amplifier.

In this case, you can first connect an external noise source (whose noise power level is known in advance) to the R&S FSW and measure the total noise power. From this value you can determine the noise power of the R&S FSW. Then when you measure the power level of the actual DUT, you can deduct the known noise level from the total power to obtain the power level of the DUT.

The noise source is controlled in the "Output" settings, see "Noise Source" on page 75

4.6.3 Receiving and Providing Trigger Signals

Using one of the variable TRIGGER INPUT/OUTPUT connectors of the R&S FSW, the R&S FSW can use a signal from an external reference as a trigger to capture data. Alternatively, the internal trigger signal used by the R&S FSW can be output for use by other connected devices. Using the same trigger on several devices is useful to synchronize the transmitted and received signals within a measurement.

For details on the connectors see the R&S FSW "Getting Started" manual.

External trigger as input

If the trigger signal for the R&S FSW is provided by an external reference, the reference signal source must be connected to the R&S FSW and the trigger source must be defined as "External" on the R&S FSW.

Trigger output

The R&S FSW can send output to another device either to pass on the internal trigger signal, or to indicate that the R&S FSW itself is ready to trigger.

The trigger signal can be output by the R&S FSW automatically, or manually by the user. If it is sent automatically, a high signal is output when the R&S FSW has triggered due to a sweep start ("Device Triggered"), or when the R&S FSW is ready to receive a trigger signal after a sweep start ("Trigger Armed").

Manual triggering

If the trigger output signal is initiated manually, the length and level (high/low) of the trigger pulse is also user-definable. Note, however, that the trigger pulse level is always opposite to the constant signal level defined by the output "Level" setting, e.g. for "Level = High", a constant high signal is output to the connector until the "Send Trigger" button is selected. Then, a low pulse is sent.

Providing trigger signals as output is described in detail in the R&S FSW User Manual.

4.7 Preparing the R&S FSW for the Expected Input Signal - Frontend Parameters

On the R&S FSW, the input data can only be processed optimally if the hardware settings match the signal characteristics as closely as possible. On the other hand, the hardware must be protected from powers or frequencies that exceed the allowed limits. Therefore, you must set the hardware so that it is optimally prepared for the expected input signal, without being overloaded. You do this using the *frontend* parameters. Consider the following recommendations:

Reference level

Adapt the R&S FSW's hardware to the expected maximum signal level by setting the "Reference Level" to this maximum. Compensate for any external attenuation or gain into consideration by defining a "Reference Level" offset.

Attenuation

To optimize the signal-to-noise ratio of the measurement for high signal levels and to protect the R&S FSW from hardware damage, provide for a high attenuation. Use AC coupling for DC input voltage.

Amplification

To optimize the signal-to-noise ratio of the measurement for low signal levels, the signal level in the R&S FSW should be as high as possible but without introducing compression, clipping, or overload. Provide for early amplification by the preamplifier and a low attenuation.

Impedance

When measuring in a 75 Ω system, connect an external matching pad to the RF input and adapt the reference impedance for power results. The insertion loss is compensated for numerically.

4.8 Triggered measurements

In a basic sweep measurement with default settings, the sweep is started immediately when you start the measurement, for example by pressing the RUN SINGLE key. However, sometimes you want the measurement to start only when a specific condition is fulfilled, for example a signal level is exceeded, or in certain time intervals. For these cases you can define a trigger for the measurement. In FFT sweep mode, the trigger defines when the data acquisition starts for the FFT conversion.

An "Offset" can be defined to delay the measurement after the trigger event, or to include data before the actual trigger event in time domain measurements (pre-trigger offset).

For complex tasks, advanced trigger settings are available:

- Hysteresis to avoid unwanted trigger events caused by noise
- Holdoff to define exactly which trigger event will cause the trigger in a jittering signal

- Trigger Offset....63
- Trigger Hysteresis....63
- Trigger Drop-Out Time....64
- Trigger Holdoff....65

4.8.1 Trigger Offset

An offset can be defined to delay the measurement after the trigger event, or to include data before the actual trigger event in time domain measurements (pre-trigger offset). Pre-trigger offsets are possible because the R&S FSW captures data continuously in the time domain, even before the trigger occurs.

See "Trigger Offset" on page 88.

4.8.2 Trigger Hysteresis

Setting a hysteresis for the trigger helps avoid unwanted trigger events caused by noise, for example. The hysteresis is a threshold to the trigger level that the signal must fall below on a rising slope or rise above on a falling slope before another trigger event occurs.

Example:

In the following example, the second possible trigger event is ignored as the signal does not exceed the hysteresis (threshold) before it reaches the trigger level again on the rising edge. On the falling edge, however, two trigger events occur as the signal exceeds the hysteresis before it falls to the trigger level the second time.

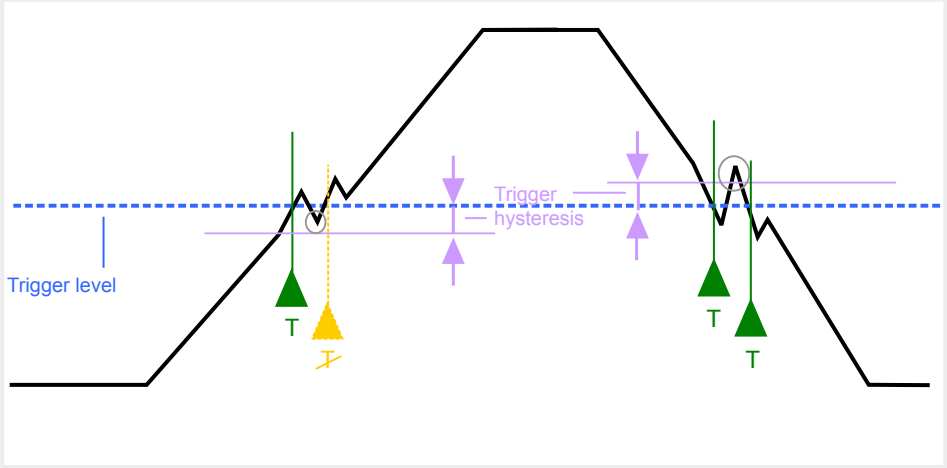


Fig. 4-3: Effects of the trigger hysteresis

See "Hysteresis" on page 89

4.8.3 Trigger Drop-Out Time

If a modulated signal is instable and produces occassional "drop-outs" during a burst, you can define a minimum duration that the input signal must stay below the trigger level before triggering again. This is called the "drop-out" time. Defining a dropout time helps you stabilize triggering when the analyzer is triggering on undesired events.

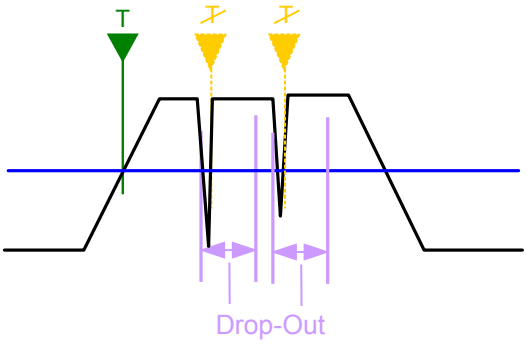


Fig. 4-4: Effect of the trigger drop-out time

See "Drop-Out Time" on page 88.

4.8.4 Trigger Holdoff

The trigger holdoff defines a waiting period before the next trigger after the current one will be recognized.

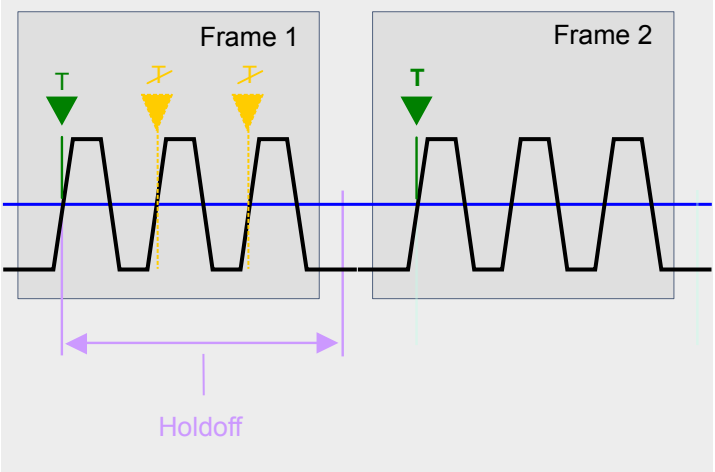


Fig. 4-5: Effect of the trigger holdoff

See "Trigger Holdoff" on page 89.

5 Configuration

The default WLAN I/Q measurement captures the I/Q data from the WLAN signal and determines various characteristic signal parameters such as the modulation accuracy, spectrum flatness, center frequency tolerance and symbol clock tolerance in just one measurement (see chapter 3.1, "WLAN I/Q Measurement (Modulation Accuracy, Flatness and Tolerance)", on page 13)

Other parameters specified in the WLAN 802.11 standard must be determined in separate measurements (see chapter 5.4, "Frequency Sweep Measurements", on page 114).

In settings required to configure each of these measurements are described here.

Selecting the measurement type

► To select a different measurement type, do one of the following:

- Tap the "Overview" softkey. In the "Overview", tap the "Select Measurement" button. Select the required measurement.
- Press the MEAS key on the front panel. In the "Select Measurement" dialog box, select the required measurement.

- Multiple Measurement Channels and Sequencer Function.....66
- Display Configuration.....68
- WLAN IQ Measurement (Modulation Accuracy, Flatness, Tolerance...).....68
- Frequency Sweep Measurements.....114

5.1 Multiple Measurement Channels and Sequencer Function

When you activate an application, a new measurement channel is created which determines the measurement settings for that application. These settings include the input source, the type of data to be processed (I/Q or RF data), frequency and level settings, measurement functions etc. If you want to perform the same measurement but with different center frequencies, for instance, or process the same input data with different measurement functions, there are two ways to do so:

- Change the settings in the measurement channel for each measurement scenario.
  In this case the results of each measurement are updated each time you change the settings and you cannot compare them or analyze them together without storing them on an external medium.
- Activate a new measurement channel for the same application.
  In the latter case, the two measurement scenarios with their different settings are displayed simultaneously in separate tabs, and you can either switch between the tabs or select the "MultiView" tab to compare the results.

For example, you can activate one WLAN measurement channel to perform a WLAN modulation accuracy measurement, and a second channel to perform an SEM measurement using the same WLAN input source.

The number of channels that can be configured at the same time depends on the available memory on the instrument.

Only one measurement can be performed on the R&S FSW at any time. If one measurement is running and you start another, or switch to another channel, the first measurement is stopped. In order to perform the different measurements you configured in multiple channels, you must switch from one tab to another.

However, you can enable a Sequencer function that automatically calls up each activated measurement channel in turn. This means the measurements configured in the channels are performed one after the other in the order of the tabs. The currently active measurement is indicated by a ✿ symbol in the tab label. The result displays of the individual channels are updated in the corresponding tab (as well as the "MultiView") as the measurements are performed. Sequencer operation is independant of the currently *displayed* tab; for example, you can analyze the SEM measurement while the modulation accuracy measurement is being performed by the Sequencer.

For details on the Sequencer function see the R&S FSW User Manual.

The Sequencer functions are only available in the "MultiView" tab.

Sequencer State.....67
Sequencer Mode.....67

Sequencer State
Activates or deactivates the Sequencer. If activated, sequential operation according to the selected Sequencer mode is started immediately.

Remote command:
`SYSTem:SEQuencer` on page 196
`INITiate:SEQuencer:IMMediate` on page 195
`INITiate:SEQuencer:ABORt` on page 195

Sequencer Mode
Defines how often which measurements are performed. The currently selected mode softkey is highlighted blue. During an active Sequencer process, the selected mode softkey is highlighted orange.

"Single Sequence"
Each measurement is performed once, until all measurements in all active channels have been performed.

"Continuous Sequence"
The measurements in each active channel are performed one after the other, repeatedly, in the same order, until sequential operation is stopped.
This is the default Sequencer mode.

"Channel-defined Sequence"
First, a single sequence is performed. Then, only channels in continuous sweep mode are repeated.

Remote command:
`INITiate:SEQuencer:MODE` on page 195

5.2 Display Configuration

The measurement results can be displayed using various evaluation methods. All evaluation methods available for the R&S FSW WLAN application are displayed in the evaluation bar in SmartGrid mode when you do one of the following:

- Select the "SmartGrid" icon from the toolbar.
- Select the "Display Config" button in the "Overview".
- Select the "Display Config" softkey in any WLAN menu.

Then you can drag one or more evaluations to the display area and configure the layout as required.

Up to 16 evaluation methods can be displayed simultaneously in separate windows. The WLAN evaluation methods are described in chapter 3, "Measurements and Result Displays", on page 13.

To close the SmartGrid mode and restore the previous softkey menu select the "Close" icon in the righthand corner of the toolbar, or press any key on the front panel.

For details on working with the SmartGrid see the R&S FSW Getting Started manual.

5.3 WLAN IQ Measurement (Modulation Accuracy, Flatness, Tolerance...)

When you activate the WLAN application, an I/Q measurement of the input signal is started automatically with the default configuration. The "WLAN" menu is displayed and provides access to the most important configuration functions. This menu is also displayed when you press the MEAS CONFIG key on the front panel.

The "Span", "Bandwidth", "Lines", and "Marker Functions" menus are not available for WLAN IQ measurements.

WLAN measurements can be configured easily in the "Overview" dialog box, which is displayed when you select the "Overview" softkey from any menu.

- Default Settings for WLAN Measurements....69
- Configuration Overview....70
- Signal Description....72
- Input and Frontend Settings....72
- Signal Capture (Data Acquisition)....82
- Synchronization and OFDM Demodulation....90
- Tracking and Channel Estimation....91
- Demodulation....93
- Evaluation Range....108
- Result Configuration....111
- Automatic Settings....111
- Sweep Settings....113
- Import/Export Functions....114

5.3.1 Default Settings for WLAN Measurements

When you activate the WLAN application the first time, a set of parameters is passed on from the currently active application:

- center frequency and frequency offset
- reference level and reference level offset
- attenuation
- input coupling
- YIG filter state

After initial setup, the parameters for the measurement channel are stored upon exiting and restored upon re-entering the channel. Thus, you can switch between applications quickly and easily.

Apart from the settings above, the following default settings are activated directly after the WLAN application is activated, or after selecting Preset Channel:

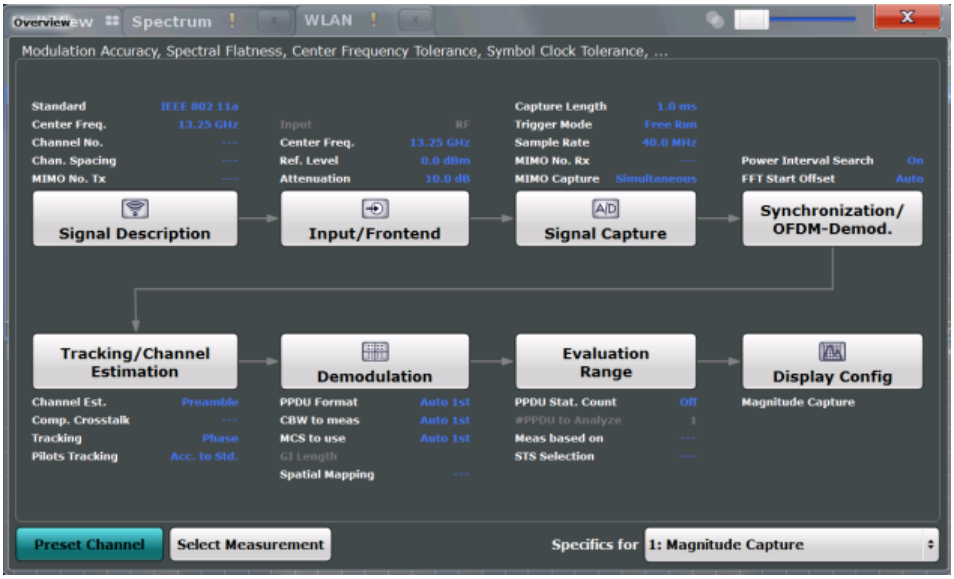
Table 5-1: Default settings for WLAN channels

Parameter	Value
Common WLAN settings	
Digital standard	IEEE 802 11a
Measurement	WLAN I/Q measurement
Input source	RF input
Attenuation	10.0 dB
Capture time	1.0 ms
Input sample rate	40.0 MHz
Trigger mode	Free run
Channel estimation	Preamble
Tracking	Phase

Parameter	Value
Pilot tracking	According to standard
PPDU format	Auto (same type as first PPDU)
Channel bandwidth to measure	Auto (same type as first PPDU)
MCS to use	Auto (same type as first PPDU)
Evaluations	Window 1: Magnitude Capture Window 2: Constellation

5.3.2 Configuration Overview

Throughout the measurement channel configuration, an overview of the most important currently defined settings is provided in the "Overview". The "Overview" is displayed when you select the "Overview" icon, which is available at the bottom of all softkey menus.



The "Overview" not only shows the main measurement settings, it also provides quick access to the main settings dialog boxes. The indicated signal flow shows which parameters affect which processing stage in the measurement. Thus, you can easily configure an entire measurement channel from input over processing to output and analysis by stepping through the dialog boxes as indicated in the "Overview".

The available settings and functions in the "Overview" vary depending on the currently selected measurement. For frequency sweep measurements see chapter 5.4, "Frequency Sweep Measurements", on page 114.

For the WLAN IQ measurement, the "Overview" provides quick access to the following configuration dialog boxes (listed in the recommended order of processing):

1. "Select Measurement"

See "Selecting the measurement type" on page 66

2. "Signal Description"
   See chapter 5.3.3, "Signal Description", on page 72
3. "Input/ Frontend"
   See and chapter 5.3.4, "Input and Frontend Settings", on page 72
4. "Signal Capture"
   See chapter 5.3.5, "Signal Capture (Data Acquisition)", on page 82
5. "Synchronization / OFDM demodulation"
   See chapter 5.3.6, "Synchronization and OFDM Demodulation", on page 90
6. "Tracking / Channel Estimation"
   See chapter 5.3.7, "Tracking and Channel Estimation", on page 91
7. "Demodulation"
   See chapter 5.3.8, "Demodulation", on page 93
8. "Evaluation Range"
   See chapter 5.3.9, "Evaluation Range", on page 108
9. "Display Configuration"
   See chapter 5.2, "Display Configuration", on page 68

To configure settings

► Select any button in the "Overview" to open the corresponding dialog box.
Select a setting in the channel bar (at the top of the measurement channel tab) to change a specific setting.

Preset Channel
Select the "Preset Channel" button in the lower lefthand corner of the "Overview" to restore all measurement settings **in the current channel** to their default values.

Note that the PRESET key on the front panel restores all measurements **in all measurement channels** on the R&S FSW to their default values!

See chapter 5.3.1, "Default Settings for WLAN Measurements", on page 69 for details.

Remote command:
`SYSTem:PRESet:CHANnel[:EXECute]` on page 135

Select Measurement
Selects a measurement to be performed.

See "Selecting the measurement type" on page 66.

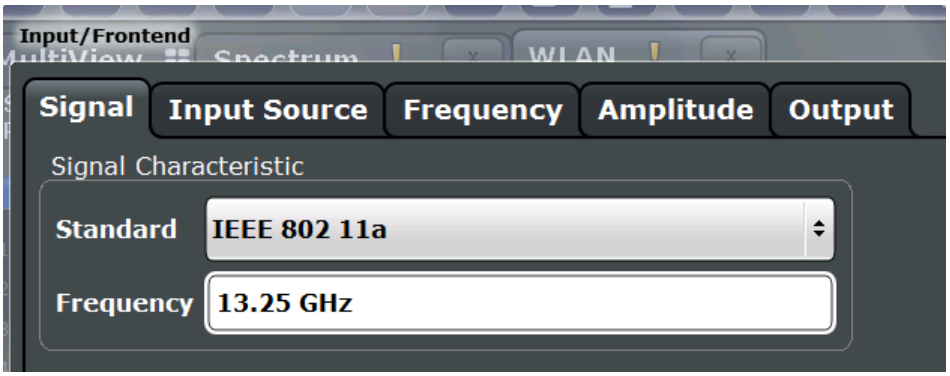
Specifics for
The measurement channel may contain several windows for different results. Thus, the settings indicated in the "Overview" and configured in the dialog boxes vary depending on the selected window.

Select an active window from the "Specifics for" selection list that is displayed in the "Overview" and in all window-specific configuration dialog boxes.

The "Overview" and dialog boxes are updated to indicate the settings for the selected window.

5.3.3 Signal Description

The signal description provides information on the expected input signal.



Standard....72
Frequency....72

Standard
Defines the WLAN standard. The measurements are performed according to the specified standard with the correct limit values and limit lines.

Many other WLAN measurement settings depend on the selected standard (see chapter 4.5, "Demodulation Parameters - Logical Filters", on page 60).

Remote command:
`CONFigure:STANdard` on page 141

Frequency
Specifies the center frequency of the signal to be measured.

Remote command:
`[SENSe:]FREQuency:CENTer` on page 145

5.3.4 Input and Frontend Settings

The R&S FSW can analyze signals from different input sources and provide various types of output (such as noise or trigger signals).

Importing and Exporting I/Q Data
The I/Q data to be analyzed for WLAN 802.11 can not only be measured by the WLAN application itself, it can also be imported to the application, provided it has the correct format. Furthermore, the analyzed I/Q data from the WLAN application can be exported for further analysis in external applications.

See chapter 5.3.13, "Import/Export Functions", on page 114.

Frequency, amplitude and y-axis scaling settings represent the "frontend" of the measurement setup.

For more information on the use and effects of these settings, see chapter 4.7, "Preparing the R&S FSW for the Expected Input Signal - Frontend Parameters", on page 62.

- Input Source Settings....73
- Output Settings....75
- Frequency Settings....77
- Amplitude Settings....78

5.3.4.1 Input Source Settings

The input source determines which data the R&S FSW will analyze.

Input settings can be configured via the INPUT/OUTPUT key, in the "Input" dialog box.

Some settings are also available in the "Amplitude" tab of the "Amplitude" dialog box.

The Digital I/Q input source is currently not available in the R&S FSW WLAN application.

- Radio Frequency Input....73

Radio Frequency Input

The default input source for the R&S FSW is "Radio Frequency", i.e. the signal at the RF INPUT connector on the front panel of the R&S FSW. If no additional options are installed, this is the only available input source.

Radio Frequency State....74
Input Coupling....74
Impedance....74
High-Pass Filter 1...3 GHz....74
YIG-Preselector....74

Radio Frequency State
Activates input from the RF INPUT connector.

Remote command:
`INPut:SELect` on page 143

Input Coupling
The RF input of the R&S FSW can be coupled by alternating current (AC) or direct current (DC).

AC coupling blocks any DC voltage from the input signal. This is the default setting to prevent damage to the instrument. Very low frequencies in the input signal may be distorted.

However, some specifications require DC coupling. In this case, you must protect the instrument from damaging DC input voltages manually. For details, refer to the data sheet.

Remote command:
`INPut:COUPling` on page 142

Impedance
The reference impedance for the measured levels of the R&S FSW can be set to 50 Ω or 75 Ω.

75 Ω should be selected if the 50 Ω input impedance is transformed to a higher impedance using a 75 Ω adapter of the RAZ type (= 25 Ω in series to the input impedance of the instrument). The correction value in this case is 1.76 dB = 10 log (75Ω/50Ω).

Remote command:
`INPut:IMPedance` on page 143

High-Pass Filter 1...3 GHz
Activates an additional internal high-pass filter for RF input signals from 1 GHz to 3 GHz. This filter is used to remove the harmonics of the R&S FSW in order to measure the harmonics for a DUT, for example.

This function requires option R&S FSW-B13.

(Note: for RF input signals outside the specified range, the high-pass filter has no effect. For signals with a frequency of approximately 4 GHz upwards, the harmonics are suppressed sufficiently by the YIG filter.)

Remote command:
`INPut:FILTer:HPASs[:STATe]` on page 142

YIG-Preselector
Activates or deactivates the YIG-preselector.

An internal YIG-preselector at the input of the R&S FSW ensures that image frequencies are rejected. However, the YIG filter may limit the bandwidth of the I/Q data and will add some magnitude and phase distortions. You can check the impact in the Spectrum Flatness and Group Delay result displays.

Note that the YIG-preselector is active only on frequencies greater than 8 GHz. Therefore, switching the YIG-preselector on or off has no effect if the frequency is below that value.

Remote command:
`INPut:FILTer:YIG[:STATe]` on page 143

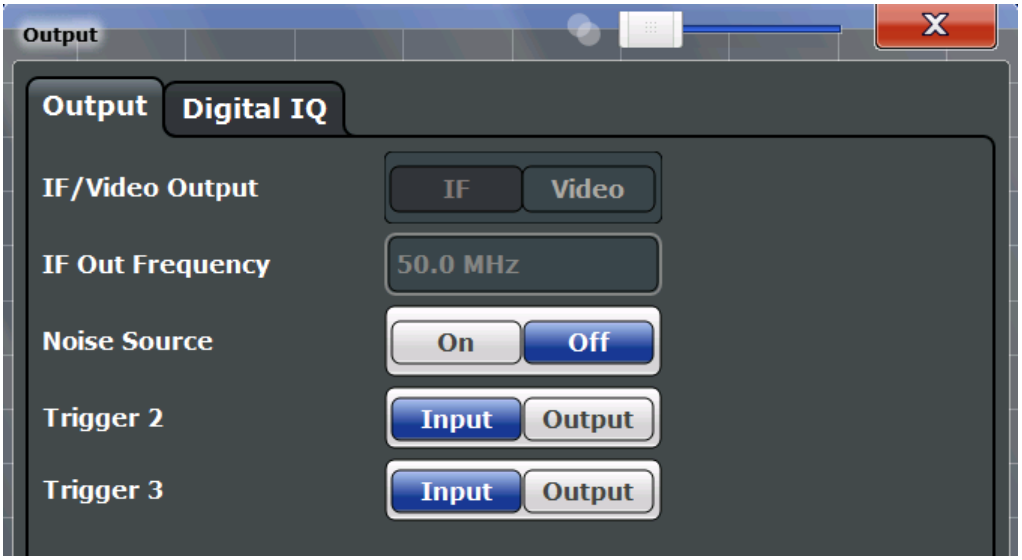
5.3.4.2 Output Settings

The R&S FSW can provide output to special connectors for other devices.

For details on connectors refer to the R&S FSW Getting Started manual, "Front / Rear Panel View" chapters.

How to provide trigger signals as output is described in detail in the R&S FSW User Manual.

Output settings can be configured via the INPUT/OUTPUT key or in the "Outputs" dialog box.



Noise Source....75
Trigger 2/3....76
└ Output Type....76
└ Level....76
└ Pulse Length....76
└ Send Trigger....77

Noise Source
Switches the supply voltage for an external noise source on or off.

External noise sources are useful when you are measuring power levels that fall below the noise floor of the R&S FSW itself, for example when measuring the noise level of a DUT.

For details see chapter 4.6.2, "Input from Noise Sources", on page 61

Remote command:
DIAGnostic:SERVice:NSOurce on page 144

Trigger 2/3
Defines the usage of the variable TRIGGER INPUT/OUTPUT connectors, where:

"Trigger 2": TRIGGER INPUT/OUTPUT connector on the front panel

"Trigger 3": TRIGGER 3 INPUT/ OUTPUT connector on the rear panel

(Trigger 1 is INPUT only.)

Note: Providing trigger signals as output is described in detail in the R&S FSW User Manual.

"Input"	The signal at the connector is used as an external trigger source by the R&S FSW. No further trigger parameters are available for the connector.
"Output"	The R&S FSW sends a trigger signal to the output connector to be used by connected devices. Further trigger parameters are available for the connector.

Remote command:
OUTPut:TRIGger<port>:LEVel on page 158
OUTPut:TRIGger<port>:DIRection on page 158

Output Type ← Trigger 2/3
Type of signal to be sent to the output

"Device Triggered"	(Default) Sends a trigger when the R&S FSW triggers.
"Trigger Armed"	Sends a (high level) trigger when the R&S FSW is in "Ready for trigger" state. This state is indicated by a status bit in the STATus:OPERation register (bit 5), as well as by a low level signal at the AUX port (pin 9).
"User Defined"	Sends a trigger when user selects "Send Trigger" button. In this case, further parameters are available for the output signal.

Remote command:
OUTPut:TRIGger<port>:OTYPe on page 159

Level ← Output Type ← Trigger 2/3
Defines whether a constant high (1) or low (0) signal is sent to the output connector.

Remote command:
OUTPut:TRIGger<port>:LEVel on page 158

Pulse Length ← Output Type ← Trigger 2/3
Defines the length of the pulse sent as a trigger to the output connector.

Remote command:
OUTPut:TRIGger<port>:PULSe:LENGth on page 160

Send Trigger ← Output Type ← Trigger 2/3
Sends a user-defined trigger to the output connector immediately. Note that the trigger pulse level is always opposite to the constant signal level defined by the output "Level" setting, e.g. for "Level = High", a constant high signal is output to the connector until the "Send Trigger" button is selected. Then, a low pulse is sent.

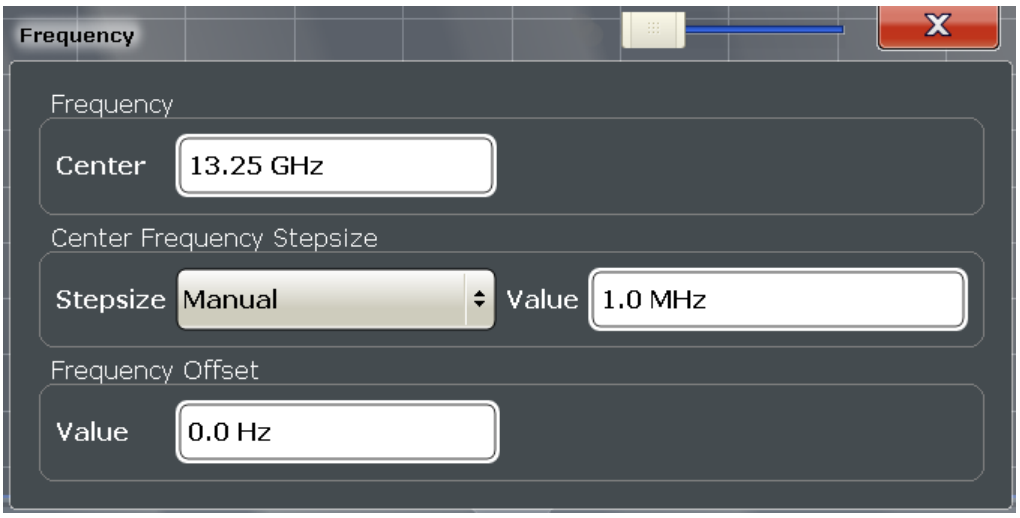
Which pulse level will be sent is indicated by a graphic on the button.

Remote command:
`OUTPut:TRIGger<port>:PULSe:IMMediate` on page 159

5.3.4.3 Frequency Settings

Frequency settings for the input signal can be configured via the "Frequency" dialog box, which is displayed when you do one of the following:

- Select the FREQ key and then the "Frequency Config" softkey.
- Select "Input/Frontend" from the "Overview" and then switch to the "Frequency" tab.



Center....77
Center Frequency Stepsize....77
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Center
Defines the normal center frequency of the signal. The allowed range of values for the center frequency depends on the frequency span.

f_{max} and $span_{min}$ are specified in the data sheet.

Remote command:
`[SENSe:]FREQuency:CENTer` on page 145

Center Frequency Stepsize
Defines the step size by which the center frequency is increased or decreased when the arrow keys are pressed. When you use the rotary knob the center frequency changes in steps of only 1/10 of the "Center Frequency Stepsize".

The step size can be coupled to another value or it can be manually set to a fixed value.

"= Center" Sets the step size to the value of the center frequency. The used value is indicated in the "Value" field.

"Manual" Defines a fixed step size for the center frequency. Enter the step size in the "Value" field.

Remote command:
`[SENSe:]FREQuency:CENTer:STEP` on page 145

Frequency Offset
Shifts the displayed frequency range along the x-axis by the defined offset.

This parameter has no effect on the R&S FSW hardware, or on the captured data or on data processing. It is simply a manipulation of the final results in which absolute frequency values are displayed. Thus, the x-axis of a spectrum display is shifted by a constant offset if it shows absolute frequencies, but not if it shows frequencies relative to the signal's center frequency.

A frequency offset can be used to correct the display of a signal that is slightly distorted by the measurement setup, for example.

The allowed values range from -100 GHz to 100 GHz. The default setting is 0 Hz.

Note: In MSRA mode, this function is only available for the MSRA Master.

Remote command:
`[SENSe:]FREQuency:OFFSet` on page 146

5.3.4.4 Amplitude Settings

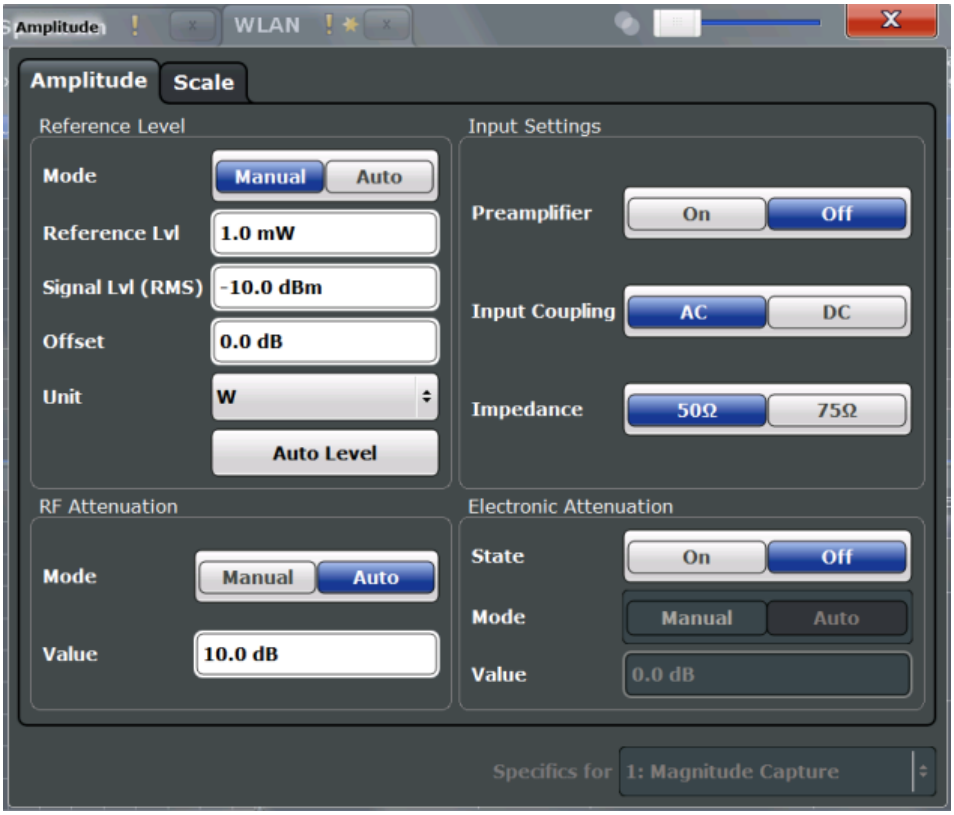
Amplitude settings determine how the R&S FSW must process or display the expected input power levels.

To configure the amplitude settings

Amplitude settings can be configured via the AMPT key or in the "Amplitude" dialog box.

► To display the "Amplitude" dialog box, do one of the following:

- Select "Input/Frontend" from the "Overview" and then switch to the "Amplitude" tab.
- Select the AMPT key and then the "Amplitude Config" softkey.



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└ Reference Level Mode....79
└ Reference Level....80
└ Signal Level (RMS)....80
└ Shifting the Display (Offset)....80
└ Unit....80
└ Setting the Reference Level Automatically (Auto Level)....81
RF Attenuation....81
└ Attenuation Mode / Value....81
Using Electronic Attenuation (Option B25)....81
Input Settings....82
└ Preamplifier (option B24)....82

Reference Level Settings

The reference level defines the expected maximum signal level. Signal levels above this value may not be measured correctly, which is indicated by the "IF OVLD" status display.

Reference Level Mode ← Reference Level Settings

By default, the reference level is automatically adapted to its optimal value for the current input data (continuously). At the same time, the internal attenuators and the preamplifier are adjusted so the signal-to-noise ratio is optimized, while signal compression, clipping and overload conditions are minimized.

In order to define the reference level manually, switch to "Manual" mode. In this case you must define the following reference level parameters.

Remote command:
CONF:POW:AUTO ON, see CONFigure:POWer:AUTO on page 181

Reference Level ← Reference Level Settings
Defines the expected maximum signal level. Signal levels above this value may not be measured correctly, which is indicated by the "IF OVLD" status display.

This value is overwritten if "Auto Level" mode is turned on.

Remote command:
DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:RLEVel on page 147

Signal Level (RMS) ← Reference Level Settings
Specifies the mean power level of the source signal as supplied to the instrument's RF input. This value is overwritten if "Auto Level" mode is turned on.

Remote command:
CONFigure:POWer:EXPected:RF on page 147

Shifting the Display (Offset) ← Reference Level Settings
Defines an arithmetic level offset. This offset is added to the measured level irrespective of the selected unit. The scaling of the y-axis is changed accordingly.

Define an offset if the signal is attenuated or amplified before it is fed into the R&S FSW so the application shows correct power results. All displayed power level results will be shifted by this value.

Note, however, that the Reference Level value ignores the "Reference Level Offset". It is important to know the actual power level the R&S FSW must handle.

To determine the required offset, consider the external attenuation or gain applied to the input signal. A positive value indicates that an attenuation took place (R&S FSW increases the displayed power values) , a negative value indicates an external gain (R&S FSW decreases the displayed power values).

The setting range is ±200 dB in 0.01 dB steps.

Remote command:
DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:RLEVel:OFFSet on page 148

Unit ← Reference Level Settings
The R&S FSW measures the signal voltage at the RF input. In the default state, the level is displayed at a power of 1 mW (= dBm). Via the known input impedance (50 Ω or 75 Ω, see "Impedance" on page 74), conversion to other units is possible. The following units are available and directly convertible:

- dBm
- dBmV
- dBµV
- dBµA
- dBpW
- Volt
- Ampere

- Watt

Remote command:
INPut:IMPedance on page 143
CALCulate<n>:UNIT:POWer on page 147

Setting the Reference Level Automatically (Auto Level) ← Reference Level Settings
Automatically determines the optimal reference level for the current input data. At the same time, the internal attenuators and the preamplifier are adjusted so the signal-to-noise ratio is optimized, while signal compression, clipping and overload conditions are minimized.

In order to do so, a level measurement is performed to determine the optimal reference level.

You can change the measurement time for the level measurement if necessary (see "Changing the Automatic Measurement Time (Meastime Manual)" on page 112).

Remote command:
CONFigure:POWer:AUTO on page 147

RF Attenuation
Defines the attenuation applied to the RF input.

Attenuation Mode / Value ← RF Attenuation
The RF attenuation can be set automatically as a function of the selected reference level (Auto mode). This ensures that the optimum RF attenuation is always used. It is the default setting. By default and when Using Electronic Attenuation (Option B25) is not available, mechanical attenuation is applied.

In "Manual" mode, you can set the RF attenuation in 1 dB steps (down to 0 dB, also using the rotary knob). Other entries are rounded to the next integer value. The range is specified in the data sheet. If the defined reference level cannot be set for the defined RF attenuation, the reference level is adjusted accordingly and the warning "Limit reached" is displayed.

NOTICE! Risk of hardware damage due to high power levels. When decreasing the attenuation manually, ensure that the power level does not exceed the maximum level allowed at the RF input, as an overload may lead to hardware damage.

Remote command:
INPut:ATTenuation on page 148
INPut:ATTenuation:AUTO on page 148

Using Electronic Attenuation (Option B25)
If option R&S FSW-B25 is installed, you can also activate an electronic attenuator.

In "Auto" mode, the settings are defined automatically; in "Manual" mode, you can define the mechanical and electronic attenuation separately.

Note: Electronic attenuation is not available for stop frequencies (or center frequencies in zero span) >13.6 GHz.
In "Auto" mode, RF attenuation is provided by the electronic attenuator as much as possible to reduce the amount of mechanical switching required. Mechanical attenuation may provide a better signal-to-noise ratio, however.

When you switch off electronic attenuation, the RF attenuation is automatically set to the same mode (auto/manual) as the electronic attenuation was set to. Thus, the RF attenuation may be set to automatic mode, and the full attenuation is provided by the mechanical attenuator, if possible.

Both the electronic and the mechanical attenuation can be varied in 1 dB steps. Other entries are rounded to the next lower integer value.

If the defined reference level cannot be set for the given attenuation, the reference level is adjusted accordingly and the warning "Limit reached" is displayed in the status bar.

Remote command:
`INPut:EATT:STATe` on page 149
`INPut:EATT:AUTO` on page 149
`INPut:EATT` on page 149

Input Settings
Some input settings affect the measured amplitude of the signal, as well.

The parameters "Input Coupling" and "Impedance" are identical to those in the "Input" settings, see chapter 5.3.4.1, "Input Source Settings", on page 73.

Preamplifier (option B24) ← Input Settings
If option R&S FSW-B24 is installed, a preamplifier can be activated for the RF input signal.

For R&S FSW 26 models, the input signal is amplified by 30 dB if the preamplifier is activated.

For R&S FSW 8 or 13 models, the following settings are available:

You can use a preamplifier to analyze signals from DUTs with low input power.

"Off" Deactivates the preamplifier.

"15 dB" The RF input signal is amplified by about 15 dB.

"30 dB" The RF input signal is amplified by about 30 dB.

Remote command:
`INPut:GAIN:STATe` on page 150
`INPut:GAIN[:VALue]` on page 150

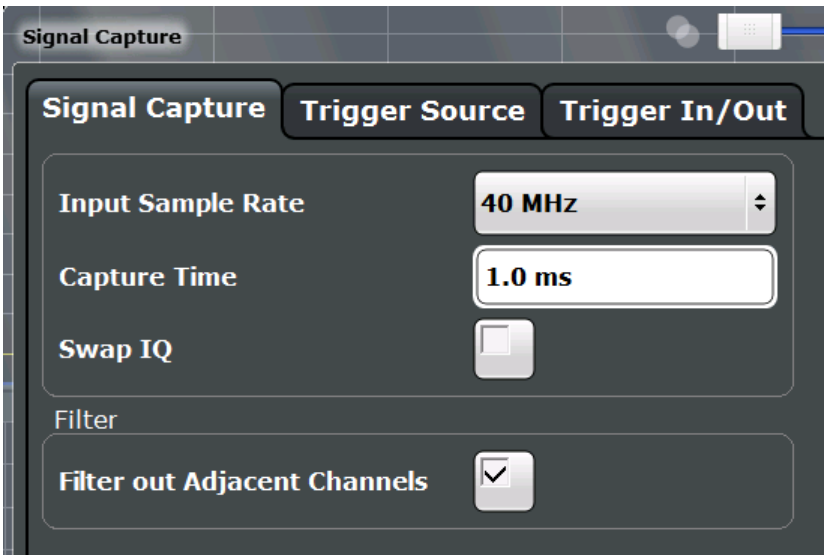
5.3.5 Signal Capture (Data Acquisition)

You can define how much and how data is captured from the input signal.

- General Capture Settings....82
- Trigger Settings....84

5.3.5.1 General Capture Settings

The general capture settings define how much and which data is to be captured during the WLAN IQ measurement.



Input Sample Rate....83
Capture Time....83
Swap I/Q....83
Suppressing (Filter out) Adjacent Channels (IEEE 802.11A, G (OFDM), AC, N)....84

Input Sample Rate
This is the sample rate the R&S FSW WLAN application expects the I/Q input data to have. If necessary, the R&S FSW has to resample the data.

During data processing in the R&S FSW, the sample rate usually changes (decreases). The RF input is captured by the R&S FSW using a high sample rate, and is resampled before it is processed by the R&S FSW WLAN application.

Remote command:
`TRACe:IQ:SRATe` on page 152

Capture Time
Specifies the duration (and therefore the amount of data) to be captured in the capture buffer. If the capture time is too short, demodulation will fail.

Remote command:
`[SENSe:]SWEep:TIME` on page 152

Swap I/Q
Activates or deactivates the inverted I/Q modulation. If the I and Q parts of the signal from the DUT are interchanged, the R&S FSW can do the same to compensate for it.

On	I and Q signals are interchanged Inverted sideband, Q+j*I
Off	I and Q signals are not interchanged Normal sideband, I+j*Q

Remote command:
`[SENSe:]SWAPiq` on page 151

Suppressing (Filter out) Adjacent Channels (IEEE 802.11A, G (OFDM), AC, N)
If activated (default), only the useful signal is analyzed, all signal data in adjacent channels is removed by the filter.

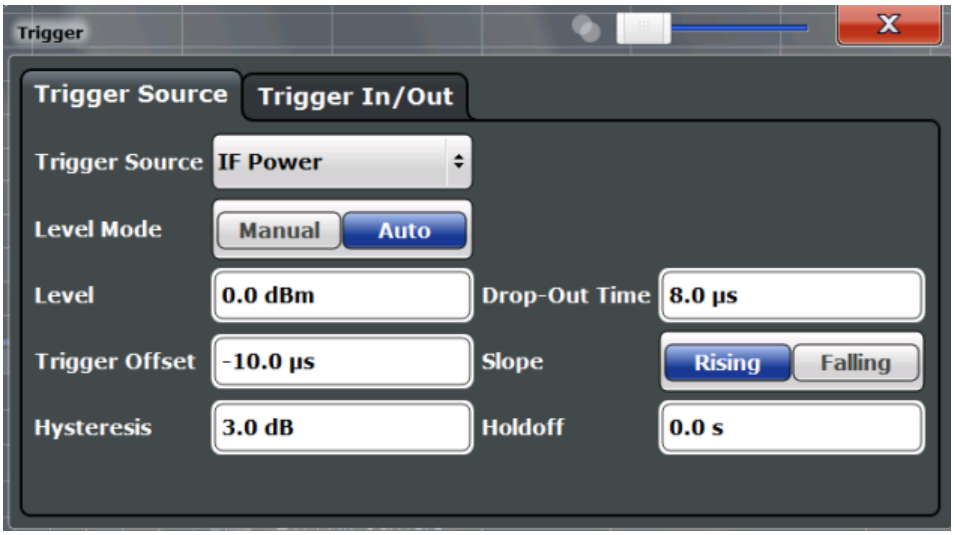
This setting improves the signal to noise ratio and thus the EVM results for signals with strong or a large number of adjacent channels. However, for some measurements information on the effects of adjacent channels on the measured signal may be of interest.

Remote command:
`[SENSe:]BANDwidth[:RESolution]:FILTer[:STATe]` on page 151

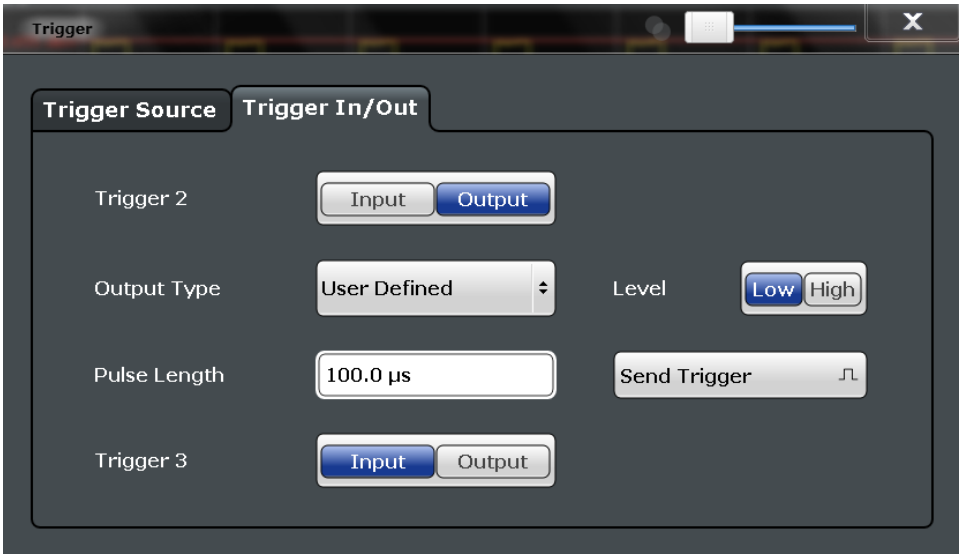
5.3.5.2 Trigger Settings

Trigger settings determine when the R&S FSW starts to capture the input signal.

Trigger settings can be configured via the TRIG key or in the "Trigger" dialog box, which is displayed when you select the "Trigger" button in the "Overview".



External triggers from one of the TRIGGER INPUT/OUTPUT connectors on the R&S FSW are configured in a separate tab of the dialog box.



For more information on trigger settings and step-by-step instructions on configuring triggered measurements, see the R&S FSW User Manual.

Trigger Source Settings....85
└ Trigger Source....86
└ Free Run....86
└ External Trigger 1/2/3....86
└ IF Power....86
└ I/Q Power....87
└ RF Power....87
└ Time....87
└ Power Sensor....87
└ Trigger Level Mode....88
└ Trigger Level....88
└ Repetition Interval....88
└ Drop-Out Time....88
└ Trigger Offset....88
└ Hysteresis....89
└ Trigger Holdoff....89
└ Slope....89
Trigger 2/3....89
└ Output Type....90
└ Level....90
└ Pulse Length....90
└ Send Trigger....90

Trigger Source Settings
The Trigger Source settings define when data is captured.

Trigger Source ← Trigger Source Settings
Defines whether a trigger is to be considered at all and if so, which signal (IF, RF, power sensor, external signal etc.) will provide the trigger signal. If a trigger source other than "Free Run" is set, "TRG" is displayed in the channel bar and the trigger source is indicated.

Remote command:
`TRIGger[:SEQuence]:SOURce` on page 156

Free Run ← Trigger Source ← Trigger Source Settings
No trigger source is considered. Data acquisition is started manually or automatically and continues until stopped explicitely.

Remote command:
`TRIG:SOUR IMM`, see `TRIGger[:SEQuence]:SOURce` on page 156

External Trigger 1/2/3 ← Trigger Source ← Trigger Source Settings
Data acquisition starts when the TTL signal fed into the specified input connector (on the front or rear panel) meets or exceeds the specified trigger level.

(See "Trigger Level" on page 88).

Note: The "External Trigger 1" softkey automatically selects the trigger signal from the TRIGGER INPUT connector on the front panel.

For details see the "Instrument Tour" chapter in the R&S FSW Getting Started manual.

"External Trigger 1"
Trigger signal from the TRIGGER INPUT connector on the front panel.

"External Trigger 2"
Trigger signal from the TRIGGER INPUT/OUTPUT connector on the front panel.
Note: Connector must be configured for "Input" in the "Outputs" configuration (see "Trigger 2/3" on page 76).

"External Trigger 3"
Trigger signal from the TRIGGER 3 INPUT/ OUTPUT connector on the rear panel.
Note: Connector must be configured for "Input" in the "Outputs" configuration (see "Trigger 2/3" on page 76).

Remote command:
`TRIG:SOUR EXT`, `TRIG:SOUR EXT2`, `TRIG:SOUR EXT3`
See `TRIGger[:SEQuence]:SOURce` on page 156

IF Power ← Trigger Source ← Trigger Source Settings
The R&S FSW starts capturing data as soon as the trigger level is exceeded around the third intermediate frequency.

This trigger source is only available for RF input.

For frequency sweeps, the third IF represents the start frequency. The trigger bandwidth at the third IF depends on the RBW and sweep type.

For measurements on a fixed frequency (e.g. zero span or I/Q measurements), the third IF represents the center frequency.

The available trigger levels depend on the RF attenuation and preamplification. A reference level offset, if defined, is also considered.

For details on available trigger levels and trigger bandwidths see the data sheet.

Remote command:
`TRIG:SOUR IFP`, see `TRIGger[:SEQuence]:SOURce` on page 156

I/Q Power ← Trigger Source ← Trigger Source Settings
This trigger source is not available if the optional Digital Baseband Interface (R&S FSW-B17) or Analog Baseband Interface (R&S FSW-B71) is used for input. It is also not available for analysis bandwidths ≥ 320 MHz.

Triggers the measurement when the magnitude of the sampled I/Q data exceeds the trigger threshold.

The trigger bandwidth corresponds to the "Usable I/Q Bandwidth", which depends on the sample rate of the captured I/Q data (see "Input Sample Rate" on page 83 and chapter A.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 230).

Remote command:
`TRIG:SOUR IQP`, see `TRIGger[:SEQuence]:SOURce` on page 156

RF Power ← Trigger Source ← Trigger Source Settings
Defines triggering of the measurement via signals which are outside the displayed measurement range.

For this purpose the instrument uses a level detector at the first intermediate frequency. The input signal must be in the frequency range between 500 MHz and 8 GHz. The resulting trigger level at the RF input depends on the RF attenuation and preamplification. For details on available trigger levels see the data sheet.

Note: If the input signal contains frequencies outside of this range (e.g. for fullspan measurements), the sweep may be aborted and a message indicating the allowed input frequencies is displayed in the status bar.

A "Trigger Offset", "Trigger Polarity" and "Trigger Holdoff" (to improve the trigger stability) can be defined for the RF trigger, but no "Hysteresis".

Remote command:
`TRIG:SOUR RFP`, see `TRIGger[:SEQuence]:SOURce` on page 156

Time ← Trigger Source ← Trigger Source Settings
Triggers in a specified repetition interval.

Remote command:
`TRIG:SOUR TIME`, see `TRIGger[:SEQuence]:SOURce` on page 156

Power Sensor ← Trigger Source ← Trigger Source Settings
Uses an external power sensor as a trigger source. This option is only available if a power sensor is connected and configured.

Note: For R&S power sensors, the "Gate Mode" *Lvl* is not supported. The signal sent by these sensors merely reflects the instant the level is first exceeded, rather than a time period. However, only time periods can be used for gating in level mode. Thus, the trigger

impulse from the sensors is not long enough for a fully gated measurement; the measurement cannot be completed.

Remote command:
`TRIG:SOUR PSE`, see `TRIGger[:SEQuence]:SOURce` on page 156

Trigger Level Mode ← Trigger Source Settings
By default, the optimum trigger level for power triggers is automatically measured and determined at the start of each sweep (for Modulation Accuracy, Flatness, Tolerance... measurements).

In order to define the trigger level manually, switch to "Manual" mode.

Remote command:
`TRIG:SEQ:LEV:POW:AUTO ON`, see `TRIGger:SEQuence:LEVel:POWer:AUTO` on page 155

Trigger Level ← Trigger Source Settings
Defines the trigger level for the specified trigger source.

For details on supported trigger levels, see the data sheet.

Remote command:
`TRIGger[:SEQuence]:LEVel:IFPower` on page 155
`TRIGger[:SEQuence]:LEVel:IQPower` on page 155
`TRIGger[:SEQuence]:LEVel[:EXTernal<port>]` on page 154
`TRIGger[:SEQuence]:LEVel:RFPower` on page 156

Repetition Interval ← Trigger Source Settings
Defines the repetition interval for a time trigger. The shortest interval is 2 ms.

The repetition interval should be set to the exact pulse period, burst length, frame length or other repetitive signal characteristic.

Remote command:
`TRIGger[:SEQuence]:TIME:RINTerval` on page 157

Drop-Out Time ← Trigger Source Settings
Defines the time the input signal must stay below the trigger level before triggering again.

For more information on the drop-out time see chapter 4.8.3, "Trigger Drop-Out Time", on page 64.

Remote command:
`TRIGger[:SEQuence]:DTIMe` on page 153

Trigger Offset ← Trigger Source Settings
Defines the time offset between the trigger event and the start of the sweep.

For more information see chapter 4.8.1, "Trigger Offset", on page 63.

offset > 0:	Start of the sweep is delayed
offset < 0:	Sweep starts earlier (pre-trigger)

Remote command:
`TRIGger[:SEQuence]:HOLDoff[:TIME]` on page 153

Hysteresis ← Trigger Source Settings
Defines the distance in dB to the trigger level that the trigger source must exceed before a trigger event occurs. Settting a hysteresis avoids unwanted trigger events caused by noise oscillation around the trigger level.

This setting is only available for "IF Power" trigger sources. The range of the value is between 3 dB and 50 dB with a step width of 1 dB.

For more information see chapter 4.8.2, "Trigger Hysteresis", on page 63.

Remote command:
`TRIGger[:SEQuence]:IFPower:HYSTeresis` on page 154

Trigger Holdoff ← Trigger Source Settings
Defines the minimum time (in seconds) that must pass between two trigger events. Trigger events that occur during the holdoff time are ignored.

For more information see chapter 4.8.4, "Trigger Holdoff", on page 65.

Remote command:
`TRIGger[:SEQuence]:IFPower:HOLDoff` on page 153

Slope ← Trigger Source Settings
For all trigger sources except time you can define whether triggering occurs when the signal rises to the trigger level or falls down to it.

Remote command:
`TRIGger[:SEQuence]:SLOPe` on page 156

Trigger 2/3
Defines the usage of the variable TRIGGER INPUT/OUTPUT connectors, where:

"Trigger 2": TRIGGER INPUT/OUTPUT connector on the front panel

"Trigger 3": TRIGGER 3 INPUT/ OUTPUT connector on the rear panel

(Trigger 1 is INPUT only.)

Note: Providing trigger signals as output is described in detail in the R&S FSW User Manual.

"Input" The signal at the connector is used as an external trigger source by the R&S FSW. No further trigger parameters are available for the connector.

"Output" The R&S FSW sends a trigger signal to the output connector to be used by connected devices.
Further trigger parameters are available for the connector.

Remote command:
`OUTPut:TRIGger<port>:LEVel` on page 158
`OUTPut:TRIGger<port>:DIRection` on page 158

Output Type ← Trigger 2/3
Type of signal to be sent to the output

"Device Triggered" (Default) Sends a trigger when the R&S FSW triggers.

"Trigger Armed" Sends a (high level) trigger when the R&S FSW is in "Ready for trigger" state.
This state is indicated by a status bit in the `STATus:OPERation` register (bit 5), as well as by a low level signal at the AUX port (pin 9).

"User Defined" Sends a trigger when user selects "Send Trigger" button.
In this case, further parameters are available for the output signal.

Remote command:
`OUTPut:TRIGger<port>:OTYPe` on page 159

Level ← Output Type ← Trigger 2/3
Defines whether a constant high (1) or low (0) signal is sent to the output connector.

Remote command:
`OUTPut:TRIGger<port>:LEVel` on page 158

Pulse Length ← Output Type ← Trigger 2/3
Defines the length of the pulse sent as a trigger to the output connector.

Remote command:
`OUTPut:TRIGger<port>:PULSe:LENGth` on page 160

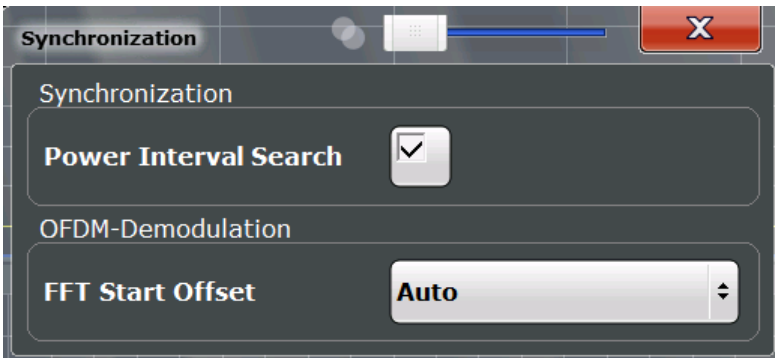
Send Trigger ← Output Type ← Trigger 2/3
Sends a user-defined trigger to the output connector immediately. Note that the trigger pulse level is always opposite to the constant signal level defined by the output "Level" setting, e.g. for "Level = High", a constant high signal is output to the connector until the "Send Trigger" button is selected. Then, a low pulse is sent.

Which pulse level will be sent is indicated by a graphic on the button.

Remote command:
`OUTPut:TRIGger<port>:PULSe:IMMediate` on page 159

5.3.6 Synchronization and OFDM Demodulation

Synchronization settings have an effect on which parts of the input signal are processed during the WLAN measurement.



Power Interval Search....91
FFT Start Offset....91

Power Interval Search
If enabled, the R&S FSW WLAN application initially performs a coarse burst search on the input signal in which increases in the power vs time trace are detected. Further time-consuming processing is then only performed where bursts are assumed. This improves the measurement speed for signals with low duty cycle rates.

However, for signals in which the PPDU power levels differ significantly, this option should be disabled as otherwise some PPDUs may not be detected.

Remote command:
`[SENSe:]DEMod:TXAREa` on page 161

FFT Start Offset
This command specifies the start offset of the FFT for OFDM demodulation (not for the FFT Spectrum display).

"AUTO"
The FFT start offset is automatically chosen to minimize the intersymbol interference.

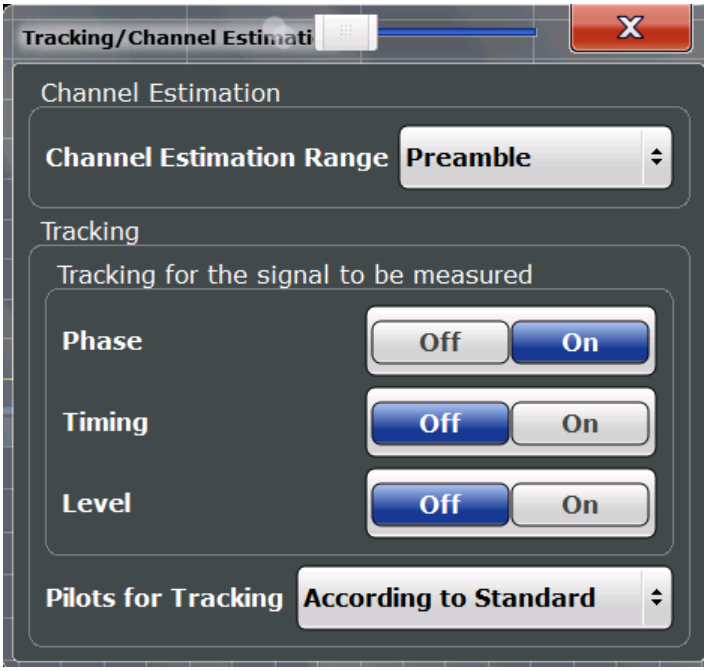
"Guard Interval Cntr"
Guard Interval Center: The FFT start offset is placed to the center of the guard interval.

"Peak"
The peak of the fine timing metric is used to determine the FFT start offset.

Remote command:
`[SENSe:]DEMod:FFT:OFFSet` on page 160

5.3.7 Tracking and Channel Estimation

The channel estimation settings determine which channels are assumed in the input signal. Tracking settings allow for compensation of some transmission effects in the signal (see "Tracking the phase drift, timing jitter and gain" on page 48).



Channel Estimation Range....92
Phase Tracking....92
Timing Error Tracking....92
Level Error (Gain) Tracking....93
Pilots for Tracking....93

Channel Estimation Range
Specifies the signal range used to estimate the channels.

This function is **not** available for **IEEE 802.11b or g (DSSS)**.

"Preamble" The channel estimation is performed in the preamble as required in the standard.

"Payload" The channel estimation is performed in the preamble and the payload. The EVM results can be calculated more accurately.

Remote command:
`[SENSe:]DEMod:CESTimation` on page 161

Phase Tracking
Activates or deactivates the compensation for phase drifts. If activated, the measurement results are compensated for phase drifts on a per-symbol basis.

Remote command:
`[SENSe:]TRACking:PHASe` on page 162

Timing Error Tracking
Activates or deactivates the compensation for timing drift. If activated, the measurement results are compensated for timing error on a per-symbol basis.

Remote command:
`[SENSe:]TRACking:TIME` on page 163

Level Error (Gain) Tracking
Activates or deactivates the compensation for level drifts within a single PPDU. If activated, the measurement results are compensated for level error on a per-symbol basis.

Remote command:
`[SENSe:]TRACking:LEVel` on page 162

Pilots for Tracking
In case tracking is used, the used pilot sequence has an effect on the measurement results.

This function is **not** available for **IEEE 802.11b or g (DSSS)**.

"According to standard"
The pilot sequence is determined according to the corresponding WLAN standard. In case the pilot generation algorithm of the device under test (DUT) has a problem, the non-standard-conform pilot sequence might affect the measurement results, or the WLAN application might not synchronize at all onto the signal generated by the DUT.

"Detected"
The pilot sequence detected in the WLAN signal to be analyzed is used by the WLAN application. In case the pilot generation algorithm of the device under test (DUT) has a problem, the non-standard-conform pilot sequence will not affect the measurement results. In case the pilot sequence generated by the DUT is correct, it is recommended that you use the "According to Standard" setting because it generates more accurate measurement results.

Remote command:
`[SENSe:]TRACking:PILots` on page 162

5.3.8 Demodulation

The demodulation settings define which PPDUs are to be analyzed, thus they define a *logical filter*.

The available demodulation settings vary depending on the selected digital standard in the "Signal Description" (see "Standard" on page 72).

- Demodulation - IEEE 802.11a, g (OFDM).....93
- Demodulation - IEEE 802.11ac.....96
- Demodulation - IEEE 802.11b, g (DSSS).....101
- Demodulation - IEEE 802.11n.....103

5.3.8.1 Demodulation - IEEE 802.11a, g (OFDM)

The following settings are available for demodulation of IEEE 802.11a, g (OFDM) signals.

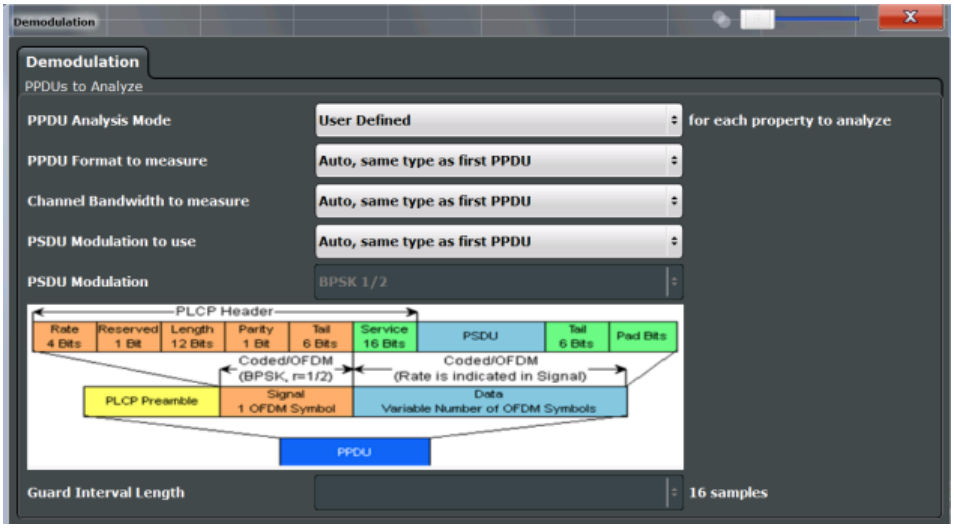


Fig. 5-1: Demodulation settings for IEEE 802.11a, or g (OFDM) standard

PPDU Analysis Mode....94
PPDU Format to measure....94
Channel Bandwidth to measure (CBW)....95
PSDU Modulation to use....95
PSDU Modulation....96

PPDU Analysis Mode
Defines whether all or only specific PPDUs are to be analyzed.

"Auto, same type as first PPDU"
The signal symbol field, i.e. the PLCP header field, of the first recognized PPDU is analyzed to determine the details of the PPDU. All PPDUs identical to the first recognized PPDU are analyzed.
All subsequent settings are set to "Auto" mode.

"Auto, individually for each PPDU"
All PPDUs are analyzed

"User-defined"
User-defined settings define which PPDUs are analyzed. This setting is automatically selected when any of the subsequent settings are changed to a value other than "Auto".

Remote command:
`[SENSe:]DEMod:FORMat[:BCONtent]:AUTO` on page 170

PPDU Format to measure
Defines which PPDU formats are to be included in the analysis. Depending on which standards the communicating devices are using, different formats of PPDUs are available. Thus you can restrict analysis to the supported formats.

Note: The PPDU format determines the available channel bandwidths.

For details on supported PPDU formats and channel bandwidths depending on the standard see table 4-1.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU""(A1st)"
The format of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same format.

"Auto, individually for each PPDU""(AI)"
All PPDUs are analyzed regardless of their format

"Meas only ...""(M ...)"
Only PPDUs with the specified format are analyzed

"Demod all as ...""(D ...)"
All PPDUs are assumed to have the specified PPDU format

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 169
`[SENSe:]DEMod:FORMat:BANalyze` on page 168

Channel Bandwidth to measure (CBW)
Defines the channel bandwidth of the PPDUs taking part in the analysis. Depending on which standards the communicating devices are using, different PPDU formats and channel bandwidths are supported.

For details on supported PPDU formats and channel bandwidths depending on the standard see table 4-1.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("CBW" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU""(A1st)"	The channel bandwidth of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same channel bandwidth.
"Auto, individually for each PPDU""(AI)"	All PPDUs are analyzed regardless of their channel bandwidth
"Meas only ... signal""(M ...)"	Only PPDUs with the specified channel bandwidth are analyzed
"Demod all as ... signal""(D ...)"	All PPDUs are assumed to have the specified channel bandwidth

Remote command:
`[SENSe:]BANDwidth:CHANnel:AUTO:TYPE` on page 166

PSDU Modulation to use
Specifies which PSDUs are to be analyzed depending on their modulation. Only PSDUs using the selected modulation are considered in measurement analysis.

For details on supported modulation depending on the standard see table 4-1.

"Auto, same type as first PPDU""(A1st)"	All PSDUs using the same modulation as the first recognized PPDU are analyzed.

"Auto, individually for each PPDU""(AI)"	All PSDUs are analyzed
"Meas only the specified PSDU Modulation""(M ...)"	Only PSDUs with the modulation specified by the "PSDU Modulation" setting are analyzed
"Demod all with specified PSDU modulation""(D ...)"	The PSDU modulation of the "PSDU Modulation" setting is used for all PSDUs.

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 169
`[SENSe:]DEMod:FORMat:BANalyze` on page 168

PSDU Modulation
If analysis is restricted to PSDU with a particular modulation type, this setting defines which type.

For details on supported modulation depending on the standard see table 4-1.

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze` on page 168

5.3.8.2 Demodulation - IEEE 802.11ac

The following settings are available for demodulation of IEEE 802.11ac signals.

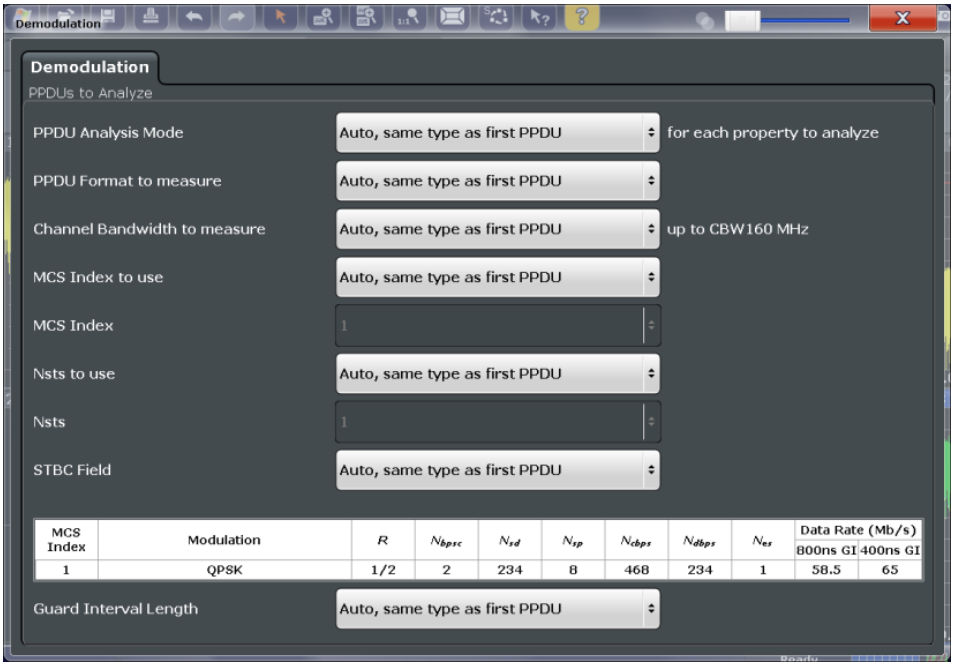


Fig. 5-2: Demodulation settings for IEEE 802.11ac standard

PPDU Analysis Mode....97
PPDU Format to measure....97
Channel Bandwidth to measure (CBW)....98
MCS Index to use....98
MCS Index....99
Nsts to use....99
Nsts....99
STBC Field....99
Table info overview....100
Guard Interval Length....101

PPDU Analysis Mode
Defines whether all or only specific PPDUs are to be analyzed.

"Auto, same type as first PPDU"
The signal symbol field, i.e. the PLCP header field, of the first recognized PPDU is analyzed to determine the details of the PPDU. All PPDUs identical to the first recognized PPDU are analyzed.
All subsequent settings are set to "Auto" mode.

"Auto, individually for each PPDU"
All PPDUs are analyzed

"User-defined"
User-defined settings define which PPDUs are analyzed. This setting is automatically selected when any of the subsequent settings are changed to a value other than "Auto".

Remote command:
`[SENSe:]DEMod:FORMat[:BCONtent]:AUTO` on page 170

PPDU Format to measure
Defines which PPDU formats are to be included in the analysis. Depending on which standards the communicating devices are using, different formats of PPDUs are available. Thus you can restrict analysis to the supported formats.

Note: The PPDU format determines the available channel bandwidths.

For details on supported PPDU formats and channel bandwidths depending on the standard see table 4-1.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU""(A1st)"
The format of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same format.

"Auto, individually for each PPDU""(AI)"
All PPDUs are analyzed regardless of their format

"Meas only ...""(M ...)"
Only PPDUs with the specified format are analyzed

"Demod all as ...""(D ...)"
All PPDUs are assumed to have the specified PPDU format

Remote command:
[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE on page 169
[SENSe:]DEMod:FORMat:BANalyze on page 168

Channel Bandwidth to measure (CBW)
Defines the channel bandwidth of the PPDUs taking part in the analysis. Depending on which standards the communicating devices are using, different PPDU formats and channel bandwidths are supported.

For details on supported PPDU formats and channel bandwidths depending on the standard see table 4-1.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("CBW" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU""(A1st)"	The channel bandwidth of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same channel bandwidth.
"Auto, individually for each PPDU""(AI)"	All PPDUs are analyzed regardless of their channel bandwidth
"Meas only ... signal""(M ...)"	Only PPDUs with the specified channel bandwidth are analyzed
"Demod all as ... signal""(D ...)"	All PPDUs are assumed to have the specified channel bandwidth

Remote command:
[SENSe:]BANDwidth:CHANnel:AUTO:TYPE on page 166

MCS Index to use
Defines the PPDUs taking part in the analysis depending on their Modulation and Coding Scheme (MCS) index.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("MCS" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU:""(A1st)"	All PPDUs using the MCS index identical to the first recognized PPDU are analyzed.
" Auto, individually for each PPDU""(AI)"	All PPDUs are analyzed
"Meas only the specified MCS""(M ...)"	Only PPDUs with the MCS index specified for the MCS Index setting are analyzed

"Demod all with specified MCS""(D ...)" The MCS Index setting is used for all PPDUs.

Remote command:
[SENSe:]DEMod:FORMat:MCSindex:MODE on page 170

MCS Index
Defines the MCS index of the PPDUs taking part in the analysis manually. This field is enabled for "MCS index to use" = "Meas only the specified MCS" or "Demod all with specified MCS".

Remote command:
[SENSe:]DEMod:FORMat:MCSindex on page 170

Nsts to use
Defines the the PPDUs taking part in the analysis depending on their Nsts.

Note: The terms in brackets in the following description indicate how the setting is referred to in the "Signal Field" result display ("NSTS" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU:""(A1st)" All PPDUs using the Nsts identical to the first recognized PPDU are analyzed.

" Auto, individually for each PPDU""(AI)" All PPDUs are analyzed

"Meas only the specified Nsts""(M ...)" Only PPDUs with the Nsts specified for the "Nsts" on page 99 setting are analyzed

"Demod all with specified Nsts""(D ...)" The "Nsts" on page 99 setting is used for all PPDUs.

Remote command:
[SENSe:]DEMod:FORMat:NSTSindex:MODE on page 171

Nsts
Defines the Nsts of the PPDUs taking part in the analysis. This field is enabled for Nsts to use = "Meas only the specified Nsts" or "Demod all with specified Nsts".

Remote command:
[SENSe:]DEMod:FORMat:NSTSindex on page 171

STBC Field
Defines the PPDUs taking part in the analysis according to the Space-Time Block Coding (STBC) field content.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("STBC" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU""(A1st)"	All PPDUs using a STBC field content identical to the first recognized PPDU are analyzed.
"Auto, individually for each PPDU""(AI)"	All PPDUs are analyzed.
"Meas only if STBC field = 1 (+1 Stream)""(M1)" (IEEE 802.11N)	Only PPDUs with the specified STBC field content are analyzed.
"Meas only if STBC field = 2 (+2 Stream)""(M2)" (IEEE 802.11N)	Only PPDUs with the specified STBC field content are analyzed.
"Demod all as STBC field = 1""(D1)"(IEEE 802.11N)	All PPDUs are analyzed assuming the specified STBC field content.
"Demod all as STBC field = 2""(D2)"(IEEE 802.11N)	All PPDUs are analyzed assuming the specified STBC field content.
"Meas only if STBC = 1 (Nsts = 2Nss)""(M1)"(IEEE 802.11AC)	Only PPDUs with the specified STBC field content are analyzed.
"Demod all as STBC = 1 (Nsts = 2Nss)""(D1)"(IEEE 802.11AC)	All PPDUs are analyzed assuming the specified STBC field content.

Remote command:
`CONFigure:WLAN:STBC:AUTO:TYPE` on page 166

Table info overview
Depending on the selected channel bandwidth, MCS index or NSS (STBC), the relevant information from the modulation and coding scheme (MCS) as defined in the WLAN 802.11 standard is displayed here. This information is for reference only, for example so you can determine the required data rate.

Guard Interval Length
Defines the PPDUs taking part in the analysis depending on the guard interval length.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("GI" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU""(A1st)"	All PPDUs using the guard interval length identical to the first recognized PPDU are analyzed.
"Auto, individually for each PPDU""(AI)"	All PPDUs are analyzed.
"Meas only Short""(MS)"	Only PPDUs with short guard interval length are analyzed.
"Meas only Long""(ML)"	Only PPDUs with long guard interval length are analyzed.
"Demod all as short""(DS)"	All PPDUs are demodulated assuming short guard interval length.
"Demod all as long ""(DL)"	All PPDUs are demodulated assuming long guard interval length.

Remote command:
`CONFigure:WLAN:GTIMe:AUTO` on page 164
`CONFigure:WLAN:GTIMe:AUTO:TYPE` on page 164
`CONFigure:WLAN:GTIMe:SELect` on page 165

5.3.8.3 Demodulation - IEEE 802.11b, g (DSSS)

The following settings are available for demodulation of IEEE 802.11b or g (DSSS) signals.

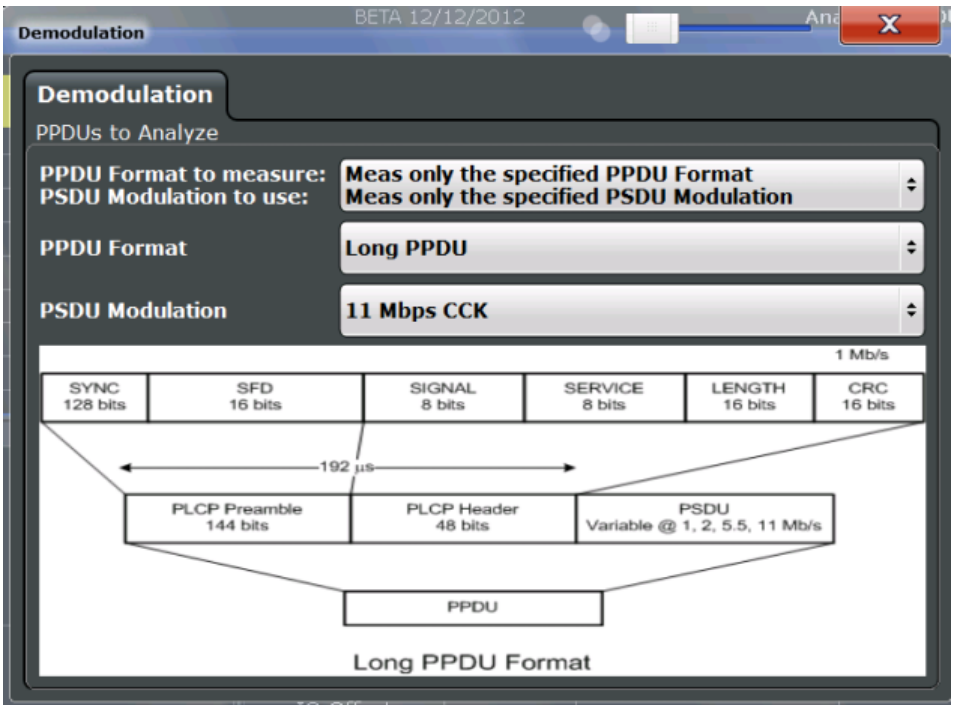


Fig. 5-3: Demodulation settings for IEEE 802.11b, g (DSSS) signals

PPDU Format to measure / PSDU Modulation to use.....102
PPDU Format.....103
PSDU Modulation.....103

PPDU Format to measure / PSDU Modulation to use
Defines which PPDU formats/modulations are to be included in the analysis. Depending on which standards the communicating devices are using, different formats of PPDUs are available. Thus you can restrict analysis to the supported formats.

Note: The PPDU format determines the available channel bandwidths.

For details on supported PPDU formats, modulations, and channel bandwidths depending on the standard see table 4-1.

"Auto, same type as first PPDU"
The format/modulation of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same format.

"Auto, individually for each PPDU"
All PPDUs are analyzed regardless of their format/modulation

"Meas only ..."
Only PPDUs with the specified format or PSDUs with the specified modulation are analyzed

"Demod all as ..."
All PPDUs are assumed to have the specified PPDU format/ PSDU modulation

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 169
`[SENSe:]DEMod:FORMat:BANalyze` on page 168

PPDU Format
If analysis is restricted to PPDUs with a particular format (see PPDU Format to measure / PSDU Modulation to use), this setting defines which type.

For details on supported modulation depending on the standard see table 4-1.

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze` on page 168

PSDU Modulation
If analysis is restricted to PSDU with a particular modulation type, this setting defines which type.

For details on supported modulation depending on the standard see table 4-1.

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze` on page 168

5.3.8.4 Demodulation - IEEE 802.11n

The following settings are available for demodulation of IEEE 802.11n signals.

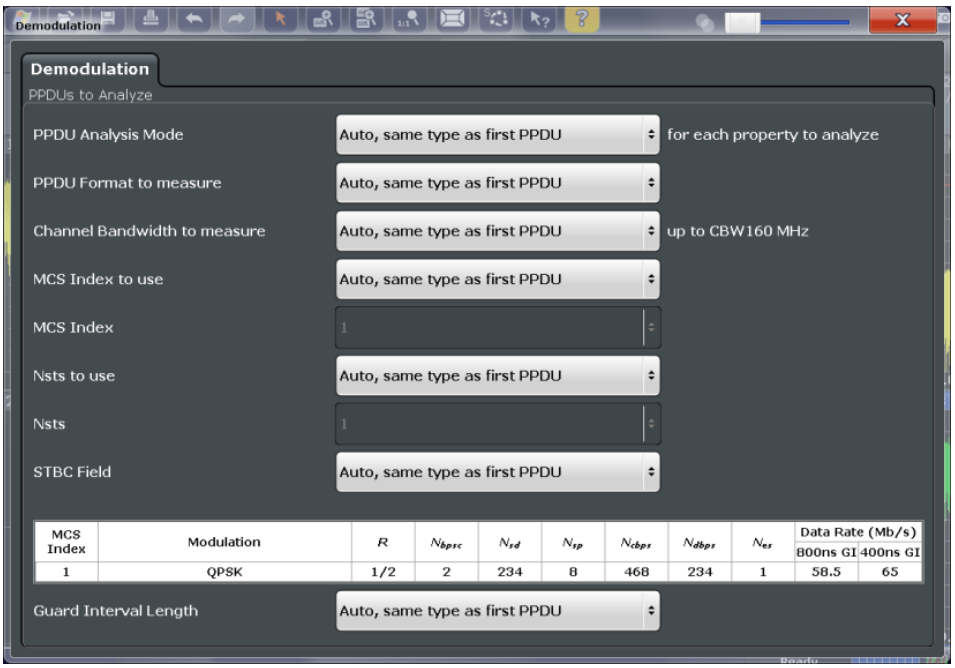


Fig. 5-4: Demodulation settings for IEEE 802.11n standard

PPDU Analysis Mode....104
PPDU Format to measure....104
Channel Bandwidth to measure (CBW)....105
MCS Index to use....105
MCS Index....106
STBC Field....106
Extension Spatial Streams (sounding)....107
Table info overview....107
Guard Interval Length....107

PPDU Analysis Mode
Defines whether all or only specific PPDUs are to be analyzed.

"Auto, same type as first PPDU"
The signal symbol field, i.e. the PLCP header field, of the first recognized PPDU is analyzed to determine the details of the PPDU. All PPDUs identical to the first recognized PPDU are analyzed.
All subsequent settings are set to "Auto" mode.

"Auto, individually for each PPDU"
All PPDUs are analyzed

"User-defined"
User-defined settings define which PPDUs are analyzed. This setting is automatically selected when any of the subsequent settings are changed to a value other than "Auto".

Remote command:
`[SENSe:]DEMod:FORMat[:BCONtent]:AUTO` on page 170

PPDU Format to measure
Defines which PPDU formats are to be included in the analysis. Depending on which standards the communicating devices are using, different formats of PPDUs are available. Thus you can restrict analysis to the supported formats.

Note: The PPDU format determines the available channel bandwidths.

For details on supported PPDU formats and channel bandwidths depending on the standard see table 4-1.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU""(A1st)"
The format of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same format.

"Auto, individually for each PPDU""(AI)"
All PPDUs are analyzed regardless of their format

"Meas only ...""(M ...)"
Only PPDUs with the specified format are analyzed

"Demod all as ...""(D ...)"
All PPDUs are assumed to have the specified PPDU format

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 169
`[SENSe:]DEMod:FORMat:BANalyze` on page 168

Channel Bandwidth to measure (CBW)
Defines the channel bandwidth of the PPDUs taking part in the analysis. Depending on which standards the communicating devices are using, different PPDU formats and channel bandwidths are supported.

For details on supported PPDU formats and channel bandwidths depending on the standard see table 4-1.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("CBW" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU""(A1st)" — The channel bandwidth of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same channel bandwidth.

"Auto, individually for each PPDU""(AI)" — All PPDUs are analyzed regardless of their channel bandwidth

"Meas only ... signal""(M ...)" — Only PPDUs with the specified channel bandwidth are analyzed

"Demod all as ... signal""(D ...)" — All PPDUs are assumed to have the specified channel bandwidth

Remote command:
`[SENSe:]BANDwidth:CHANnel:AUTO:TYPE` on page 166

MCS Index to use
Defines the PPDUs taking part in the analysis depending on their Modulation and Coding Scheme (MCS) index.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("MCS" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU:""(A1st)" — All PPDUs using the MCS index identical to the first recognized PPDU are analyzed.

" Auto, individually for each PPDU""(AI)" — All PPDUs are analyzed

"Meas only the specified MCS""(M ...)" — Only PPDUs with the MCS index specified for the MCS Index setting are analyzed

"Demod all with specified MCS""(D ...)" The MCS Index setting is used for all PPDUs.

Remote command:
[SENSe:]DEMod:FORMat:MCSindex:MODE on page 170

MCS Index
Defines the MCS index of the PPDUs taking part in the analysis manually. This field is enabled for "MCS index to use" = "Meas only the specified MCS" or "Demod all with specified MCS".

Remote command:
[SENSe:]DEMod:FORMat:MCSindex on page 170

STBC Field
Defines the PPDUs taking part in the analysis according to the Space-Time Block Coding (STBC) field content.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("STBC" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU""(A1st)" All PPDUs using a STBC field content identical to the first recognized PPDU are analyzed.

"Auto, individually for each PPDU""(AI)" All PPDUs are analyzed.

"Meas only if STBC field = 1 (+1 Stream)""(M1)" (IEEE 802.11N) Only PPDUs with the specified STBC field content are analyzed.

"Meas only if STBC field = 2 (+2 Stream)""(M2)" (IEEE 802.11N) Only PPDUs with the specified STBC field content are analyzed.

"Demod all as STBC field = 1""(D1)"(IEEE 802.11N) All PPDUs are analyzed assuming the specified STBC field content.

"Demod all as STBC field = 2""(D2)"(IEEE 802.11N) All PPDUs are analyzed assuming the specified STBC field content.

"Meas only if STBC = 1 (Nsts = 2Nss)""(M1)"(IEEE 802.11AC)	Only PPDUs with the specified STBC field content are analyzed.
"Demod all as STBC = 1 (Nsts = 2Nss)""(D1)"(IEEE 802.11AC)	All PPDUs are analyzed assuming the specified STBC field content.

Remote command:
`CONFigure:WLAN:STBC:AUTO:TYPE` on page 166

Extension Spatial Streams (sounding)
Defines the PPDUs taking part in the analysis according to the Ness field content.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("NESS" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU""(A1st)"	All PPDUs using a Ness value identical to the first recognized PPDU are analyzed.
"Auto, individually for each PPDU""(AI)"	All PPDUs are analyzed.
"Meas only if Ness = <x>""(M ...)"	Only PPDUs with the specified Ness value are analyzed.
"Demod all as Ness = <x>"	All PPDUs are analyzed assuming the specified Ness value.

Remote command:
`CONFigure:WLAN:EXTension:AUTO:TYPE` on page 163

Table info overview
Depending on the selected channel bandwidth, MCS index or NSS (STBC), the relevant information from the modulation and coding scheme (MCS) as defined in the WLAN 802.11 standard is displayed here. This information is for reference only, for example so you can determine the required data rate.

Guard Interval Length
Defines the PPDUs taking part in the analysis depending on the guard interval length.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("GI" column, see "Signal Field" on page 35).

"Auto, same type as first PPDU""(A1st)"	All PPDUs using the guard interval length identical to the first recognized PPDU are analyzed.

"Auto, individually for each PPDU""(AI)"	All PPDUs are analyzed.
"Meas only Short""(MS)"	Only PPDUs with short guard interval length are analyzed.
"Meas only Long""(ML)"	Only PPDUs with long guard interval length are analyzed.
"Demod all as short""(DS)"	All PPDUs are demodulated assuming short guard interval length.
"Demod all as long ""(DL)"	All PPDUs are demodulated assuming long guard interval length.

Remote command:
`CONFigure:WLAN:GTIMe:AUTO` on page 164
`CONFigure:WLAN:GTIMe:AUTO:TYPE` on page 164
`CONFigure:WLAN:GTIMe:SELect` on page 165

5.3.9 Evaluation Range

The evaluation range defines which objects the result displays are based on.

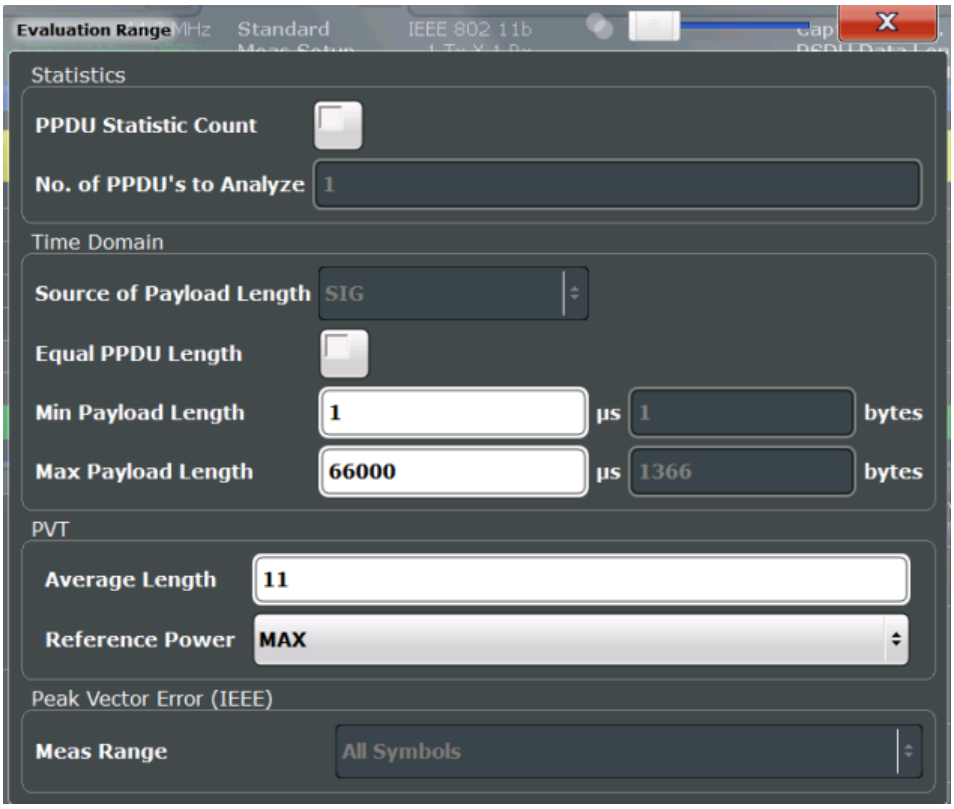


Fig. 5-5: Evaluation range settings for IEEE 802.11b and g (DSSS) standards

PPDU Statistic Count / No of PPDUs to Analyze....109
Source of Payload Length (IEEE 802.11 AC, N)....109
Equal PPDU Length....109
(Min./Max.) No. of Data Symbols (IEEE 802.11a, g (OFDM), ac, n)....109
(Min./Max.) Payload Length (IEEE 802.11b, g (DSSS))....110
PVT : Average Length (IEEE 802.11b, g (DSSS))....110
PVT : Reference Power (IEEE 802.11b, g (DSSS))....110
Peak Vector Error : Meas Range (IEEE 802.11 B, G (DSSS))....110

PPDU Statistic Count / No of PPDUs to Analyze
If the statistic count is enabled, the specified number of PPDUs is taken into consideration for the statistical evaluation. Sweeps are performed continuously until the required number of PPDUs are available. The number of captured and required PPDUs, as well as the number of PPDUs detected in the current sweep, are indicated as "Analyzed PPDUs" in the channel bar (see "Channel bar information" on page 10).

If disabled, all valid PPDUs in the current capture buffer are considered. Note that in this case, the number of PPDUs contributing to the current results may vary extremely.

Remote command:
`[SENSe:]BURSt:COUNt:STATe` on page 174
`[SENSe:]BURSt:COUNt` on page 174

Source of Payload Length (IEEE 802.11 AC, N)
Defines which signal source is used to determine the payload length of a PPDU.

"L-Signal"(IEEE 802.11 AC)
Determines the length of the L signal

"HT-Signal"(IEEE 802.11 N)
Determines the length of the HT signal

"Estimate from signal"
Uses an estimated length

Remote command:
`CONFigure:WLAN:PAYLoad:LENGth:SRC` on page 173

Equal PPDU Length
If enabled, only PPDUs with the specified (Min./Max.) Payload Length (IEEE 802.11b, g (DSSS)) are considered for measurement analysis.

If disabled, a maximum and minimum (Min./Max.) Payload Length (IEEE 802.11b, g (DSSS)) can be defined and all PPDUs whose length is within this range are considered.

Remote command:
IEEE 802.11a, g (OFDM):
`[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal` on page 177
IEEE 802.11 b, g (DSSS):
`[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal` on page 175
`[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal` on page 174

(Min./Max.) No. of Data Symbols (IEEE 802.11a, g (OFDM), ac, n)
If the Equal PPDU Length setting is enabled, the number of data symbols defines the exact length a PPDU must have to be considered for analysis.

If the Equal PPDU Length setting is disabled, you can define the minimum and maximum number of data symbols a PPDU must contain to be considered in measurement analysis.

Remote command:
[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MIN on page 177

(Min./Max.) Payload Length (IEEE 802.11b, g (DSSS))
If the Equal PPDU Length setting is enabled, the payload length defines the exact length a PPDU must have to be considered for analysis.

If the Equal PPDU Length setting is disabled, you can define the minimum and maximum payload length a PPDU must contain to be considered in measurement analysis.

The payload length can be defined as a duration in µs or a number of bytes (only if specific PPDU modulation and format are defined for analysis, see "PPDU Format to measure / PSDU Modulation to use" on page 102).

Remote command:
[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MIN on page 175
[SENSe:]DEMod:FORMat:BANalyze:DURation:MIN on page 176
[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MAX on page 175
[SENSe:]DEMod:FORMat:BANalyze:DURation:MAX on page 176

PVT : Average Length (IEEE 802.11b, g (DSSS))
Defines the number of samples used to adjust the length of the smoothing filter for PVT measurement.

For details see "PvT Full PPDU" on page 31.

Remote command:
CONFigure:BURSt:PVT:AVERage on page 173

PVT : Reference Power (IEEE 802.11b, g (DSSS))
Sets the reference for the rise and fall time in PVT calculation to the maximum or mean PPDU power.

For details see "PvT Full PPDU" on page 31.

Remote command:
CONFigure:BURSt:PVT:RPOWer on page 173

Peak Vector Error : Meas Range (IEEE 802.11 B, G (DSSS))
Displays the used measurement range for peak vector error measurement (for reference only).

"All Symbols" Peak Vector Error results are calculated over the complete PPDU

"PSDU only" Peak Vector Error results are calculated over the PSDU only

Remote command:
CONFigure:WLAN:PVERror:MRANge? on page 173

5.3.10 Result Configuration

You can configure which results are displayed in Result Summary displays (see "Result Summary Detailed" on page 32 and "Result Summary Global" on page 33). However, the results are always *calculated*, regardless of their visibility on the screen.

The "Result Configuration" softkey in the main WLAN menu opens the "Result Configuration" dialog box. This softkey is only available if a window with a "Result Summary Detailed" or "Result Summary Global" result display is displayed. This window must be focussed or you must select it from the "Specifics for" selection list in the "Overview".

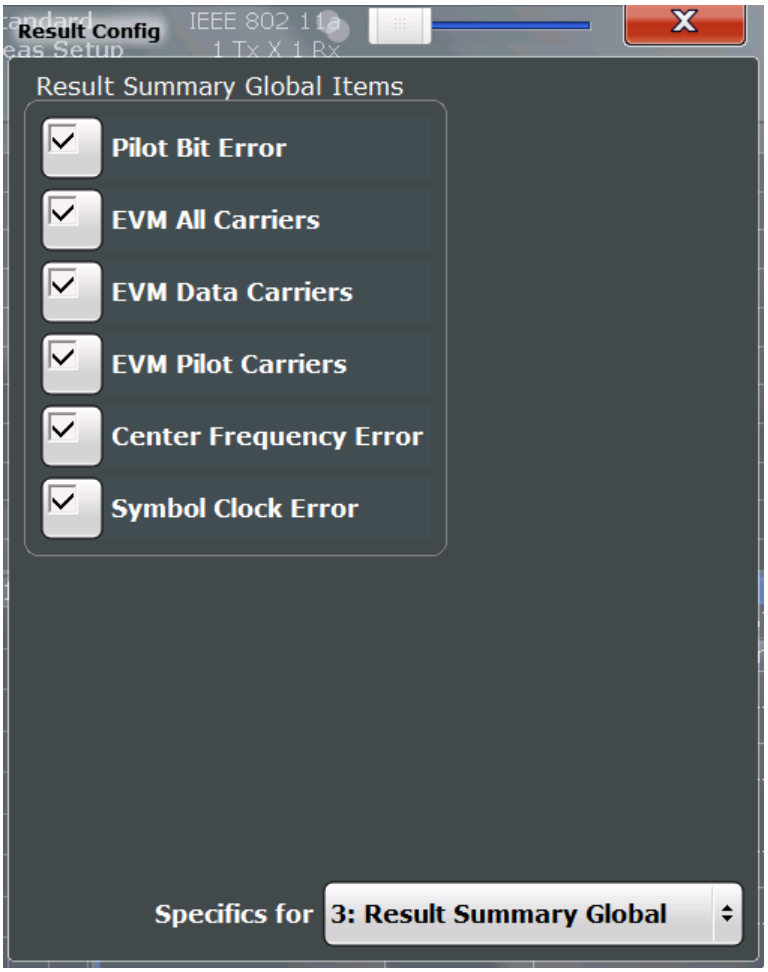


Fig. 5-6: Result Summary Global configuration for IEEE 802.11a, g (OFDM) standards

Remote command:

`DISPlay[:WINDow<n>]:TABLe:ITEM` on page 192

5.3.11 Automatic Settings

Some settings can be adjusted by the R&S FSW automatically according to the current measurement settings and signal characteristics.

To activate the automatic adjustment of a setting, select the corresponding function in the AUTO SET menu or in the configuration dialog box for the setting, where available.

Setting the Reference Level Automatically (Auto Level)....112
Resetting the Automatic Measurement Time (Meastime Auto)....112
Changing the Automatic Measurement Time (Meastime Manual)....112
Upper Level Hysteresis....112
Lower Level Hysteresis....112

Setting the Reference Level Automatically (Auto Level)
Automatically determines the optimal reference level for the current input data. At the same time, the internal attenuators and the preamplifier (for analog baseband input: the full scale level) are adjusted so the signal-to-noise ratio is optimized, while signal compression, clipping and overload conditions are minimized.

In order to do so, a level measurement is performed to determine the optimal reference level.

Remote command:
`[SENSe:]ADJust:LEVel` on page 183

Resetting the Automatic Measurement Time (Meastime Auto)
Resets the measurement duration for automatic settings to the default value.

Remote command:
`[SENSe:]ADJust:CONFigure:DURation:MODE` on page 182

Changing the Automatic Measurement Time (Meastime Manual)
This function allows you to change the measurement duration for automatic setting adjustments. Enter the value in seconds.

Remote command:
`[SENSe:]ADJust:CONFigure:DURation:MODE` on page 182
`[SENSe:]ADJust:CONFigure:DURation` on page 181

Upper Level Hysteresis
When the reference level is adjusted automatically using the Auto Level function, the internal attenuators and the preamplifier are also adjusted. In order to avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines an upper threshold the signal must exceed (compared to the last measurement) before the reference level is adapted automatically.

Remote command:
`[SENSe:]ADJust:CONFigure:HYSTeresis:UPPer` on page 183

Lower Level Hysteresis
When the reference level is adjusted automatically using the Auto Level function, the internal attenuators and the preamplifier are also adjusted. In order to avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines a lower threshold the signal must fall below (compared to the last measurement) before the reference level is adapted automatically.

Remote command:
`[SENSe:]ADJust:CONFigure:HYSTeresis:LOWer` on page 182

5.3.12 Sweep Settings

The sweep settings define how the data is measured.

Sweep Count....113
Continuous Sweep/RUN CONT....113
Single Sweep/ RUN SINGLE....113
Continue Single Sweep....113

Sweep Count
This setting is currently ignored. For statistical evaluation see "PPDU Statistic Count / No of PPDUs to Analyze" on page 109.

Continuous Sweep/RUN CONT
While the measurement is running, the "Continuous Sweep" softkey and the RUN CONT key are highlighted. The running measurement can be aborted by selecting the highlighted softkey or key again. The results are not deleted until a new measurement is started.

Note: Sequencer. If the Sequencer is active, the "Continuous Sweep" softkey only controls the sweep mode for the currently selected channel; however, the sweep mode only has an effect the next time the Sequencer activates that channel, and only for a channel-defined sequence. In this case, a channel in continuous sweep mode is swept repeatedly. Furthermore, the RUN CONT key on the front panel controls the Sequencer, not individual sweeps. RUN CONT starts the Sequencer in continuous mode.

Remote command:
`INITiate:CONTinuous` on page 194

Single Sweep/ RUN SINGLE
While the measurement is running, the "Single Sweep" softkey and the RUN SINGLE key are highlighted. The running measurement can be aborted by selecting the highlighted softkey or key again.

Note: Sequencer. If the Sequencer is active, the "Single Sweep" softkey only controls the sweep mode for the currently selected channel; however, the sweep mode only has an effect the next time the Sequencer activates that channel, and only for a channel-defined sequence. In this case, a channel in single sweep mode is swept only once by the Sequencer.
Furthermore, the RUN SINGLE key on the front panel controls the Sequencer, not individual sweeps. RUN SINGLE starts the Sequencer in single mode.

If the Sequencer is off, only the evaluation for the currently displayed measurement channel is updated.

Remote command:
`INITiate[:IMMediate]` on page 194

Continue Single Sweep
While the measurement is running, the "Continue Single Sweep" softkey and the RUN SINGLE key are highlighted. The running measurement can be aborted by selecting the highlighted softkey or key again.

5.3.13 Import/Export Functions

The following import and export functions are available via softkeys in the "Save/Recall" menu which is displayed when you select the "Save" or "Open" icon in the toolbar.

For a description of the other functions in the "Save/Recall" menu see the R&S FSW User Manual.

Export....114
└ IQ Export....114
Import....114
└ IQ Import....114

Export
Opens a submenu to configure data export.

IQ Export ← Export
Opens a file selection dialog box to select an export file to which the IQ data will be stored. This function is only available in single sweep mode, and only in applications that process I/Q data, such as the I/Q Analyzer or optional applications.

For details see chapter 5.3.13, "Import/Export Functions", on page 114.

Remote command:
`MMEMory:STORe:IQ:STATe` on page 220

Import
Provides functions to import data.

IQ Import ← Import
Opens a file selection dialog box to select an import file that contains IQ data. This function is only available in single sweep mode and only in applications that process I/Q data, such as the I/Q Analyzer or optional applications.

Note that the I/Q data must have a specific format as described in chapter A.2, "I/Q Data File Format (iq-tar)", on page 234.

I/Q import is not available in MSRA mode.

For details see chapter 5.3.13, "Import/Export Functions", on page 114.

Remote command:
`MMEMory:LOAD:IQ:STATe` on page 220

5.4 Frequency Sweep Measurements

When you activate a measurement channel in WLAN mode, an IQ measurement of the input signal is started automatically (see chapter 3.1, "WLAN I/Q Measurement (Modulation Accuracy, Flatness and Tolerance)", on page 13). However, some parameters specified in the WLAN 802.11 standard require a better signal-to-noise level or a smaller

bandwidth filter than the default measurement on I/Q data provides and must be determined in separate measurements based on RF data (see chapter 3.2, "Frequency Sweep Measurements", on page 39). In these measurements, demodulation is not performed.

Selecting the measurement type

WLAN measurements require a special operating mode on the R&S FSW, which you activate using the MODE key on the front panel.

► To select a frequency sweep measurement type, do one of the following:

- Tap the "Overview" softkey. In the "Overview", tap the "Select Measurement" button. Select the required measurement.
- Press the MEAS key on the front panel. In the "Select Measurement" dialog box, select the required measurement.

The R&S FSW WLAN application uses the functionality of the R&S FSW base system (Spectrum application) to perform the WLAN frequency sweep measurements. Some parameters are set automatically according to the WLAN 802.11 standard the first time a measurement is selected (since the last PRESET operation). These parameters can be changed, but are not reset automatically the next time you re-enter the measurement. Refer to the description of each measurement type for details.

The main measurement configuration menus for the WLAN frequency sweep measurements are identical to the Spectrum application.

For details refer to "Measurements" in the R&S FSW User Manual.

The measurement-specific settings for the following measurements are available via the "Overview".

- Channel Power (ACLR) Measurements.....115
- Spectrum Emission Mask.....116
- Occupied Bandwidth.....117
- CCDF.....118

5.4.1 Channel Power (ACLR) Measurements

The Adjacent Channel Power measurement analyzes the power of the TX channel and the power of adjacent and alternate channels on the left and right side of the TX channel. The number of TX channels and adjacent channels can be modified as well as the band class. The bandwidth and power of the TX channel and the bandwidth, spacing and power of the adjacent and alternate channels are displayed in the Result Summary.

Channel Power ACLR measurements are performed as in the Spectrum application with the following predefined settings according to WLAN specifications (adjacent channel leakage ratio).

Table 5-2: Predefined settings for WLAN ACLR Channel Power measurements

Setting	Default value
ACLR Standard	same as defined in WLAN signal description (see "Standard" on page 72)
Number of adjacent channels	3
Reference channel	Max power Tx channel
Channel bandwidth	20 MHz

For further details about the ACLR measurements refer to "Measuring Channel Power and Adjacent-Channel Power" in the R&S FSW User Manual.

To restore adapted measurement parameters, the following parameters are saved on exiting and are restored on re-entering this measurement:

- Reference level and reference level offset
- RBW, VBW
- Sweep time
- Span
- Number of adjacent channels
- Fast ACLR mode

The main measurement menus for the frequency sweep measurements are identical to the Spectrum application.

5.4.2 Spectrum Emission Mask

The Spectrum Emission Mask measurement shows the quality of the measured signal by comparing the power values in the frequency range near the carrier against a spectral mask that is defined by the WLAN 802.11 specifications. The limits depend on the selected power class. Thus, the performance of the DUT can be tested and the emissions and their distance to the limit are identified.

Note that the WLAN standard does not distinguish between spurious and spectral emissions.

The Result Summary contains a peak list with the values for the largest spectral emissions including their frequency and power.

The WLAN application performs the SEM measurement as in the Spectrum application with the following settings:

Table 5-3: Predefined settings for WLAN SEM measurements

Setting	Default value
Number of ranges	3
Frequency Span	+/- 12.75 MHz

Setting	Default value
Fast SEM	OFF
Sweep time	140 µs
RBW	30 kHz
Power reference type	Channel Power
Tx Bandwidth	3.84 MHz
Number of power classes	1

You must select the SEM file with the pre-defined settings required by the standard manually (using the "Standard Files" softkey in the main "SEMask" menu). The subdirectory displayed in the SEM standard file selection dialog box depends on the standard you selected previously for the WLAN Modulation Accuracy, Flatness,... measurement (see "Standard" on page 72).

For further details about the Spectrum Emission Mask measurements refer to "Spectrum Emission Mask Measurement" in the R&S FSW User Manual.

To restore adapted measurement parameters, the following parameters are saved on exiting and are restored on re-entering this measurement:

- Reference level and reference level offset
- Sweep time
- Span

The main measurement menus for the frequency sweep measurements are identical to the Spectrum application.

5.4.3 Occupied Bandwidth

The Occupied Bandwidth measurement is performed as in the Spectrum application with default settings.

Table 5-4: Predefined settings for WLAN OBW measurements

Setting	Default value
% Power Bandwidth	99 %
Channel bandwidth	3.84 MHz

The Occupied Bandwidth measurement determines the bandwidth that the signal occupies. The occupied bandwidth is defined as the bandwidth in which – in default settings - 99 % of the total signal power is to be found. The percentage of the signal power to be included in the bandwidth measurement can be changed.

For further details about the Occupied Bandwidth measurements refer to "Measuring the Occupied Bandwidth" in the R&S FSW User Manual.

To restore adapted measurement parameters, the following parameters are saved on exiting and are restored on re-entering this measurement:

- Reference level and reference level offset
- RBW, VBW
- Sweep time
- Span

5.4.4 CCDF

The CCDF measurement determines the distribution of the signal amplitudes (complementary cumulative distribution function). The CCDF and the Crest factor are displayed. For the purposes of this measurement, a signal section of user-definable length is recorded continuously in zero span, and the distribution of the signal amplitudes is evaluated.

The measurement is useful to determine errors of linear amplifiers. The crest factor is defined as the ratio of the peak power and the mean power. The Result Summary displays the number of included samples, the mean and peak power and the crest factor.

The CCDF measurement is performed as in the Spectrum application with the following settings:

Table 5-5: Predefined settings for WLAN CCDF measurements

Setting	Default value
CCDF	Active on trace 1
Analysis bandwidth	10 MHz
Number of samples	62500
Detector	Sample

For further details about the CCDF measurements refer to "Statistical Measurements" in the R&S FSW User Manual.

To restore adapted measurement parameters, the following parameters are saved on exiting and are restored on re-entering this measurement:

- Reference level and reference level offset
- Analysis bandwidth
- Number of samples

6 Analysis

General result analysis settings concerning the trace and markers etc. are currently not available for the standard WLAN measurements. Only one (Clear/Write) trace and one marker are available for these measurements.

Analysis of frequency sweep measurements

General result analysis settings concerning the trace, markers, lines etc. for RF measurements are identical to the analysis functions in the Spectrum application except for some special marker functions and spectrograms, which are not available in the WLAN application.

For details see the "Common Analysis and Display Functions" chapter in the R&S FSW User Manual.

The remote commands required to perform these tasks are described in chapter 9.10, "Analysis", on page 221.

7 How to Perform Measurements in the WLAN Application

The following step-by-step instructions demonstrate how to perform measurements in the R&S FSW WLAN application. The following tasks are described:

- How to Determine Modulation Accuracy, Flatness and Tolerance Parameters for WLAN Signals.....120
- How to Determine the OBW, SEM, ACLR or CCDF for WLAN Signals.....121

7.1 How to Determine Modulation Accuracy, Flatness and Tolerance Parameters for WLAN Signals

1. Press the MODE key on the front panel of the R&S FSW.

   A dialog box opens that contains all operating modes and applications currently available on your R&S FSW.

2. Select the "WLAN" item.

   The R&S FSW opens a new measurement channel for the WLAN application.

3. Select the "Overview" softkey to display the "Overview" for a WLAN measurement.
4. Select the "Signal Description" button to define the digital standard to be used.
5. Select the "Input/Frontend" button and then the "Frequency" tab to define the input signal's center frequency.

   The reference level is adapted automatically.

6. Select the "Signal Capture" button to define how much and which data to capture from the input signal.
7. To define a particular starting point for the FFT or to improve the measurement speed for signals with a low duty cycle, select the "Synchronization/OFDM-Demod." button and set the required parameters.
8. Select the "Tracking/Channel Estimation" button to define how the data channels are to be estimated and which distortions will be compensated for.
9. Select the "Demod" button to provide information on the modulated signal and how the PPDUs detected in the capture buffer are to be demodulated.
10. Select the "Evaluation Range" button to define which data in the capture buffer you want to analyze.

11. Select the "Display Config" button and select the displays that are of interest to you (up to 16).
    Arrange them on the display to suit your preferences.
12. Exit the SmartGrid mode.
13. Start a new sweep with the defined settings.
    - To perform a single sweep measurement, press the RUN SINGLE hardkey.
    - To perform a continuous sweep measurement, press the RUN CONT hardkey.

    Measurement results are updated once the measurement has completed.

7.2 How to Determine the OBW, SEM, ACLR or CCDF for WLAN Signals

1. Press the MODE key on the front panel and select the "WLAN" application.

   The R&S FSW opens a new measurement channel for the WLAN application. I/Q data acquisition is performed by default.
2. Select the "Signal Description" button to define the digital standard to be used.
3. Select the required measurement:
   a) Press the MEAS key on the front panel.
   b) In the "Select Measurement" dialog box, select the required measurement.

   The selected measurement is activated with the default settings for WLAN immediately.
4. For SEM measurements, select the required standard settings file:
   a) In the SEMask menu, select the "Standard Files" softkey.
   b) Select the required settings file. The subdirectory displayed in the file selection dialog box depends on the standard you selected in step step 2.
5. If necessary, adapt the settings as described for the individual measurements in the R&S FSW User Manual.
6. Select the "Display Config" button and select the evaluation methods that are of interest to you.
   Arrange them on the display to suit your preferences.
7. Exit the SmartGrid mode and select the "Overview" softkey to display the "Overview" again.
8. Select the "Analysis" button in the "Overview" to make use of the advanced analysis functions in the result displays.
   - Configure a trace to display the average over a series of sweeps; if necessary, increase the "Sweep Count" in the "Sweep" settings.

- Configure markers and delta markers to determine deviations and offsets within the evaluated signal.
- Use special marker functions to calculate noise or a peak list.
- Configure a limit check to detect excessive deviations.

9. Optionally, export the trace data of the graphical evaluation results to a file.
   a) In the "Traces" tab of the "Analysis" dialog box, switch to the "Trace Export" tab.
   b) Select "Export Trace to ASCII File".
   c) Define a file name and storage location and select "OK".

8 Optimizing and Troubleshooting the Measurement

- Optimizing the Measurement Results....123
- Error Messages and Warnings....124

8.1 Optimizing the Measurement Results

If the results do not meet your expectations, try the following methods to optimize the measurement.

- Improving Performance....123
- Improving Channel Estimation and EVM Accuracy....123

8.1.1 Improving Performance

Performing a coarse burst search

For signals with **low duty cycle rates**, enable the "Power Interval Search" for synchronization (see "Power Interval Search" on page 91). In this case, the R&S FSW WLAN application initially performs a coarse burst search on the input signal in which increases in the power vs time trace are detected. Further time-consuming processing is then only performed where bursts are assumed. This improves the measurement speed.

However, for signals in which the PPDU power levels differ significantly, this option should be disabled as otherwise some PPDUs may not be detected.

8.1.2 Improving Channel Estimation and EVM Accuracy

The channels in the WLAN signal are estimated based on the expected input signal description and the information provided by the PPDUs themselves. The more accurate the channel estimation, the more accurate the EVM based on these channels can be calculated.

Increasing the basis for channel estimation

The more information that can be used to estimate the channels, the more accurate the results. For measurements that need not be performed strictly according to the WLAN 802.11 standard, set the "Channel Estimation Range" to "Payload" (see "Channel Estimation Range" on page 92).

The channel estimation is performed in the preamble and the payload. The EVM results can be calculated more accurately.

Accounting for phase drift in the EVM

According to the WLAN 802.11 standards, the common phase drift must be estimated and compensated from the pilots. Thus, these deviations are not included in the EVM. To include the phase drift, disable "Phase Tracking" (see "Phase Tracking" on page 92).

Analyzing time jitter

Normally, a symbol-wise timing jitter is negligible and not required by the IEEE 802.11a measurement standard [6], and thus not considered in channel estimation. However, there may be situations where the timing drift has to be taken into account.

However, to analyze the time jitter per symbol, enable "Timing Tracking" (see "Timing Error Tracking" on page 92).

Compensating for non-standard-conform pilot sequences

In case the pilot generation algorithm of the device under test (DUT) has a problem, the non-standard-conform pilot sequence might affect the measurement results, or the WLAN application might not synchronize at all onto the signal generated by the DUT.

In this case, set the "Pilots for Tracking" to "Detected" (see "Pilots for Tracking" on page 93), so that the pilot sequence detected in the signal is used instead of the sequence defined by the standard.

However, if the pilot sequence generated by the DUT is correct, it is recommended that you use the "According to Standard" setting because it generates more accurate measurement results.

8.2 Error Messages and Warnings

The following messages are displayed in the status bar in case of errors.

Results contribute to overall results despite inconsistencies:

"Info: Comparison between HT-SIG Payload Length and Estimated Payload Length not performed due to insufficient SNR"

The R&S FSW-K91 application compares the HT-SIG length against the length estimated from the PPDU power profile. If the two values do not match, the corresponding entry is highlighted orange. If the signal quality is very bad, this comparison is suppressed and the message above is shown.

"Warning: HT-SIG of PPDU was not evaluated"

Decoding of the HT-SIG was not possible because there was to not enough data in the Capture Memory (potential PPDU truncation).

"Warning: Mismatch between HT-SIG and estimated (SNR+Power) PPDU length"

The HT-SIG length and the length estimated by the R&S FSW application (from the PPDU power profile) are different.

"Warning: Physical Channel estimation impossible / Phy Chan results not available Possible reasons: channel matrix not square or singular to working precision"

The Physical Channel results could not be calculated for one or both of the following reasons:

- The spatial mapping can not be applied due to a rectangular mapping matrix (the number of space time streams is not equal to the number of transmit antennas).
- The spatial mapping matrices are singular to working precision.

PPDUs are dismissed due to inconsistencies

"Hint: PPDU requires at least one payload symbol"

Currently at least one payload symbol is required in order to successfully analyze the PPDU. Null data packet (NDP) sounding PPDUs will generate this message.

"Hint: PPDU dismissed due to a mismatch with the PPDU format to be analyzed"

The properties causing the mismatches for this PPDU are highlighted.

"Hint: PPDU dismissed due to truncation"

The first or the last PPDU was truncated during the signal capture process, for example.

"Hint: PPDU dismissed due to HT-SIG inconsistencies"

One or more of the following HT-SIG decoding results are outside of specified range: MCS index, Number of additional STBC streams, Number of space time streams (derived from MCS and STBC), CRC Check failed, Non zero tail bits.

"Hint: PPDU dismissed because payload channel estimation was not possible"

The payload based channel estimation was not possible because the channel matrix is singular to working precision.

"Hint: Channel matrix singular to working precision"

Channel equalizing (for PPDU Length Detection, fully and user compensated measurement signal) is not possible because the estimated channel matrix is singular to working precision.

9 Remote Commands for WLAN Measurements

The following commands are required to perform measurements in the R&S FSW WLAN application in a remote environment. It assumes that the R&S FSW has already been set up for remote operation in a network as described in the base unit manual (*How to Set Up a Network and Remote Control*).

Note that basic tasks that are independant of the application are not described here. For a description of such tasks, see the R&S FSW User Manual.

In particular, this includes:

- Managing Settings and Results, i.e. storing and loading settings and result data
- Basic instrument configuration, e.g. checking the system configuration, customizing the screen layout, or configuring networks and remote operation
- Using the common status registers

After an introduction to SCPI commands, the following tasks specific to the WLAN application are described here:

- Common Suffixes....126
- Introduction....127
- Activating WLAN Measurements....132
- Selecting a Measurement....136
- Configuring the WLAN IQ Measurement (Modulation Accuracy, Flatness and Tolerance)....141
- Configuring Frequency Sweep Measurements on WLAN Signals....184
- Configuring the Result Display....184
- Starting a Measurement....193
- Retrieving Results....197
- Analysis....221
- Status Registers....224
- Commands for Compatibility....228

9.1 Common Suffixes

For the description of the remote commands in the WLAN application, the following common suffixes are used:

Table 9-1: Common suffixes for WLAN measurements on I/Q data

Suffix	Value range	Description
<n>	1..16	Window
<k>	1..8	Limit

Suffix	Value range	Description
<t>	1	Trace
<m>	1..4	Marker

Table 9-2: Common suffixes for frequency sweep measurements

Suffix	Value range	Description
<n>	1..16	Window
<t>	1..6	Trace
<m>	1..16	Marker
<ch>	1..18 (Tx channel) 1..11 (ALTernate or ADJacent channel)	Channel
<k>	1..8	Limit line

9.2 Introduction

Commands are program messages that a controller (e.g. a PC) sends to the instrument or software. They operate its functions ('setting commands' or 'events') and request information ('query commands'). Some commands can only be used in one way, others work in two ways (setting and query). If not indicated otherwise, the commands can be used for settings and queries.

The syntax of a SCPI command consists of a header and, in most cases, one or more parameters. To use a command as a query, you have to append a question mark after the last header element, even if the command contains a parameter.

A header contains one or more keywords, separated by a colon. Header and parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). If there is more than one parameter for a command, these are separated by a comma from one another.

Only the most important characteristics that you need to know when working with SCPI commands are described here. For a more complete description, refer to the User Manual of the R&S FSW.

Remote command examples

Note that some remote command examples mentioned in this general introduction may not be supported by this particular application.

9.2.1 Conventions used in Descriptions

Note the following conventions used in the remote command descriptions:

- **Command usage**

If not specified otherwise, commands can be used both for setting and for querying parameters.
If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitely.

- **Parameter usage**
  If not specified otherwise, a parameter can be used to set a value and it is the result of a query.
  Parameters required only for setting are indicated as **Setting parameters**.
  Parameters required only to refine a query are indicated as **Query parameters**.
  Parameters that are only returned as the result of a query are indicated as **Return values**.
- **Conformity**
  Commands that are taken from the SCPI standard are indicated as **SCPI confirmed**. All commands used by the R&S FSW follow the SCPI syntax rules.
- **Asynchronous commands**
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an **Asynchronous command**.
- **Reset values (*RST)**
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as ***RST** values, if available.
- **Manual operation**
  If the result of a remote command can also be achieved in manual operation, a link to the description is inserted.

9.2.2 Long and Short Form

The keywords have a long and a short form. You can use either the long or the short form, but no other abbreviations of the keywords.

The short form is emphasized in upper case letters. Note however, that this emphasis only serves the purpose to distinguish the short from the long form in the manual. For the instrument, the case does not matter.

Example:

`SENSe:FREQuency:CENTer` is the same as `SENS:FREQ:CENT`.

9.2.3 Numeric Suffixes

Some keywords have a numeric suffix if the command can be applied to multiple instances of an object. In that case, the suffix selects a particular instance (e.g. a measurement window).

Numeric suffixes are indicated by angular brackets (<n>) next to the keyword.

If you don't quote a suffix for keywords that support one, a 1 is assumed.

Example:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe` enables the zoom in a particular measurement window, selected by the suffix at `WINDow`.

`DISPlay:WINDow4:ZOOM:STATe ON` refers to window 4.

9.2.4 Optional Keywords

Some keywords are optional and are only part of the syntax because of SCPI compliance. You can include them in the header or not.

Note that if an optional keyword has a numeric suffix and you need to use the suffix, you have to include the optional keyword. Otherwise, the suffix of the missing keyword is assumed to be the value 1.

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

`[SENSe:]FREQuency:CENTer` is the same as `FREQuency:CENTer`

With a numeric suffix in the optional keyword:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe`

`DISPlay:ZOOM:STATe ON` enables the zoom in window 1 (no suffix).

`DISPlay:WINDow4:ZOOM:STATe ON` enables the zoom in window 4.

9.2.5 Alternative Keywords

A vertical stroke indicates alternatives for a specific keyword. You can use both keywords to the same effect.

Example:

`[SENSe:]BANDwidth|BWIDth[:RESolution]`

In the short form without optional keywords, `BAND 1MHZ` would have the same effect as `BWID 1MHZ`.

9.2.6 SCPI Parameters

Many commands feature one or more parameters.

If a command supports more than one parameter, these are separated by a comma.

Example:

`LAYout:ADD:WINDow Spectrum,LEFT,MTABle`

Parameters may have different forms of values.

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- Boolean....131
- Character Data....131
- Character Strings....131
- Block Data....131

9.2.6.1 Numeric Values

Numeric values can be entered in any form, i.e. with sign, decimal point or exponent. In case of physical quantities, you can also add the unit. If the unit is missing, the command uses the basic unit.

Example:

with unit: `SENSe:FREQuency:CENTer 1GHZ`

without unit: `SENSe:FREQuency:CENTer 1E9` would also set a frequency of 1 GHz.

Values exceeding the resolution of the instrument are rounded up or down.

If the number you have entered is not supported (e.g. in case of discrete steps), the command returns an error.

Instead of a number, you can also set numeric values with a text parameter in special cases.

- MIN/MAX
  Defines the minimum or maximum numeric value that is supported.
- DEF
  Defines the default value.
- UP/DOWN
  Increases or decreases the numeric value by one step. The step size depends on the setting. In some cases you can customize the step size with a corresponding command.

Querying numeric values

When you query numeric values, the system returns a number. In case of physical quantities, it applies the basic unit (e.g. Hz in case of frequencies). The number of digits after the decimal point depends on the type of numeric value.

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

Query: `SENSe:FREQuency:CENTer?` would return `1E9`

In some cases, numeric values may be returned as text.

- INF/NINF
  Infinity or negative infinity. Represents the numeric values 9.9E37 or -9.9E37.
- NAN

Not a number. Represents the numeric value 9.91E37. NAN is returned in case of errors.

9.2.6.2 Boolean

Boolean parameters represent two states. The "ON" state (logically true) is represented by "ON" or a numeric value 1. The "OFF" state (logically untrue) is represented by "OFF" or the numeric value 0.

Querying boolean parameters

When you query boolean parameters, the system returns either the value 1 ("ON") or the value 0 ("OFF").

Example:

Setting: `DISPlay:WINDow:ZOOM:STATe ON`

Query: `DISPlay:WINDow:ZOOM:STATe?` would return `1`

9.2.6.3 Character Data

Character data follows the syntactic rules of keywords. You can enter text using a short or a long form. For more information see chapter 9.2.2, "Long and Short Form", on page 128.

Querying text parameters

When you query text parameters, the system returns its short form.

Example:

Setting: `SENSe:BANDwidth:RESolution:TYPE NORMal`

Query: `SENSe:BANDwidth:RESolution:TYPE?` would return `NORM`

9.2.6.4 Character Strings

Strings are alphanumeric characters. They have to be in straight quotation marks. You can use a single quotation mark (') or a double quotation mark (").

Example:

```
INSTRument:DELete 'Spectrum'
```

9.2.6.5 Block Data

Block data is a format which is suitable for the transmission of large amounts of data.

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. In the example the 4 following digits indicate the length to be 5168 bytes. The data bytes follow. During the transmission of these data bytes all end or other control signs are ignored until all bytes are transmitted.

#0 specifies a data block of indefinite length. The use of the indefinite format requires a NL^END message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

9.3 Activating WLAN Measurements

WLAN measurements require a special application on the R&S FSW (R&S FSW-K91). The measurement is started immediately with the default settings.

These are basic R&S FSW commands, listed here for your convenience.

INSTrument:CREate:DUPLicate....132
INSTrument:CREate[:NEW]....132
INSTrument:CREate:REPLace....133
INSTrument:DELete....133
INSTrument:LIST?....133
INSTrument:REName....135
INSTrument[:SELect]....135
SYSTem:PRESet:CHANnel[:EXECute]....135

INSTrument:CREate:DUPLicate

This command duplicates the currently selected measurement channel, i.e starts a new measurement channel of the same type and with the identical measurement settings. The name of the new channel is the same as the copied channel, extended by a consecutive number (e.g. "Spectrum" -> "Spectrum 2").

The channel to be duplicated must be selected first using the `INST:SEL` command.

This command is not available if the MSRA Master channel is selected.

Example:
```
INST:SEL 'Spectrum'
INST:CRE:DUPL
```
Duplicates the channel named 'Spectrum' and creates a new measurement channel named 'Spectrum 2'.

Usage: Event

INSTrument:CREate[:NEW] <ChannelType>, <ChannelName>

This command adds an additional measurement channel. The number of measurement channels you can configure at the same time depends on available memory.

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types see table 9-3.

<ChannelName> String containing the name of the channel. The channel name is displayed as the tab label for the measurement channel.
Note: If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel (see table 9-3).

Example: `INST:CRE SAN, 'Spectrum 2'`
Adds an additional spectrum display named "Spectrum 2".

INSTrument:CREate:REPLace <ChannelName1>,<ChannelType>,<ChannelName2>

This command replaces a measurement channel with another one.

Parameters:

<ChannelName1> String containing the name of the measurement channel you want to replace.

<ChannelType> Channel type of the new channel.
For a list of available channel types see table 9-3.

<ChannelName2> String containing the name of the new channel.
Note: If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel (see table 9-3).

Example: `INST:CRE:REPL 'Spectrum2',IQ,'IQAnalyzer'`
Replaces the channel named 'Spectrum2' by a new measurement channel of type 'IQ Analyzer' named 'IQAnalyzer'.

INSTrument:DELete <ChannelName>

This command deletes a measurement channel. If you delete the last measurement channel, the default "Spectrum" channel is activated.

Parameters:

<ChannelName> String containing the name of the channel you want to delete.
A measurement channel must exist in order to be able delete it.

Example: `INST:DEL 'Spectrum4'`
Deletes the spectrum channel with the name 'Spectrum4'.

INSTrument:LIST?

This command queries all active measurement channels. This is useful in order to obtain the names of the existing measurement channels, which are required in order to replace or delete the channels.

Return values:

<ChannelType>, <ChannelName> For each channel, the command returns the channel type and channel name (see table 9-3).
Tip: to change the channel name, use the `INSTrument:REName` command.

Example: `INST:LIST?`
Result for 3 measurement channels:
`'ADEM','Analog Demod','IQ','IQ Analyzer','SANALYZER','Spectrum'`

Usage: Query only

Table 9-3: Available measurement channel types and default channel names

Application	<ChannelType> Parameter	Default Channel Name*)
Spectrum	SANALYZER	Spectrum
I/Q Analyzer	IQ	IQ Analyzer
Pulse (R&S FSW-K6)	PULSE	Pulse
Analog Demodulation (R&S FSW-K7)	ADEM	Analog Demod
GSM (R&S FSW-K10)	GSM	GSM
Multi-Carrier Group Delay (R&S FSW-K17)	MCGD	MC Group Delay
Noise (R&S FSW-K30)	NOISE	Noise
Phase Noise (R&S FSW-K40)	PNOISE	Phase Noise
VSA (R&S FSW-K70)	DDEM	VSA
3GPP FDD BTS (R&S FSW-K72)	BWCD	3G FDD BTS
3GPP FDD UE (R&S FSW-K73)	MWCD	3G FDD UE
TD-SCDMA BTS (R&S FSW-K76)	BTDS	TD-SCDMA BTS
TD-SCDMA UE (R&S FSW-K77)	MTDS	TD-SCDMA UE
cdma2000 BTS (R&S FSW-K82)	BC2K	CDMA2000 BTS
cdma2000 MS (R&S FSW-K83)	MC2K	CDMA2000 MS
1xEV-DO BTS (R&S FSW-K84)	BDO	1xEV-DO BTS
1xEV-DO MS (R&S FSW-K85)	MDO	1xEV-DO MS
WLAN (R&S FSW-K91)	WLAN	WLAN
LTE (R&S FSW-K10x)	LTE	LTE
Real-Time Spectrum (R&S FSW-K160R)	RTIM	Real-Time Spectrum
Note: the default channel name is also listed in the table. If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

INSTrument:REName <ChannelName1>, <ChannelName2>

This command renames a measurement channel.

Parameters:

<ChannelName1> String containing the name of the channel you want to rename.

<ChannelName2> String containing the new channel name.
Note that you can not assign an existing channel name to a new channel; this will cause an error.

Example: `INST:REN 'Spectrum2','Spectrum3'`
Renames the channel with the name 'Spectrum2' to 'Spectrum3'.

INSTrument[:SELect] <ChannelType> | <ChannelName>

This command activates a new measurement channel with the defined channel type, or selects an existing measurement channel with the specified name.

See also `INSTrument:CREate[:NEW]` on page 132.

For a list of available channel types see `INSTrument:LIST?` on page 133.

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types see table 9-3.

WLAN
WLAN option, R&S FSW–K91

<ChannelName> String containing the name of the channel.

Example: `INST WLAN`
Activates a measurement channel for the WLAN application.
`INST 'WLAN'`
Selects the measurement channel named 'WLAN' (for example before executing further commands for that channel).

SYSTem:PRESet:CHANnel[:EXECute]

This command restores the default instrument settings in the current channel.

Use `INST:SEL` to select the channel.

Example: `INST 'Spectrum2'`
Selects the channel for "Spectrum2".
`SYST:PRES:CHAN:EXEC`
Restores the factory default settings to the "Spectrum2" channel.

Usage: Event

Manual operation: See "Preset Channel" on page 71

9.4 Selecting a Measurement

The following commands are required to define the measurement type in a remote environment. The selected measurement must be started explicitely (see chapter 9.8, "Starting a Measurement", on page 193)!

For details on available measurements see chapter 3, "Measurements and Result Displays", on page 13.

The WLAN IQ measurement captures the I/Q data from the WLAN signal using a (nearly rectangular) filter with a relatively large bandwidth. This measurement is selected when the WLAN measurement channel is activated. The commands to select a different measurement or return to the WLAN IQ measurement are described here.

Note that the `CONF:BURS:<ResultType>:IMM` commands change the screen layout to display the Magnitude Capture buffer in window 1 at the top of the screen and the selected result type in window 2 below that. Any other active windows are closed.

Use the `LAYout` commands to change the display (see chapter 9.7, "Configuring the Result Display", on page 184).

- Selecting the WLAN IQ Measurement (Modulation Accuracy, Flatness and Tolerance)....136
- Selecting a Common RF Measurement for WLAN Signals....139

9.4.1 Selecting the WLAN IQ Measurement (Modulation Accuracy, Flatness and Tolerance)

Any of the following commands can be used to return to the WLAN IQ measurement. Each of these results are automatically determined when the WLAN IQ measurement is performed.

The selected measurement must be started explicitely (see chapter 9.8, "Starting a Measurement", on page 193)!

CONFigure:BURSt:CONSt:CCARrier[:IMMediate]....137
CONFigure:BURSt:CONSt:CSYMbol[:IMMediate]....137
CONFigure:BURSt:EVM:ECARrier[:IMMediate]....137
CONFigure:BURSt:EVM:ESYMbol[:IMMediate] (IEEE 802.11b and g (DSSS))....137
CONFigure:BURSt:EVM:ECHip[:IMMediate]....137
CONFigure:BURSt:EVM:ESYMbol[:IMMediate]....137
CONFigure:BURSt:PVT[:IMMediate]....138
CONFigure:BURSt:SPECtrum:FFT[:IMMediate]....138
CONFigure:BURSt:SPECtrum:FLATness:SELect....138
CONFigure:BURSt:SPECtrum:FLATness[:IMMediate]....138
CONFigure:BURSt:STATistics:BSTReam[:IMMediate]....139
CONFigure:BURSt:STATistics:SFIeld[:IMMediate]....139
DISPlay[:WINDow<n>]:SELect....139

CONFigure:BURSt:CONSt:CCARrier[:IMMediate]

This remote control command configures the result display type of window 2 to be Constellation vs Carrier. Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command.

Usage: Event

Manual operation: See "Constellation vs Carrier" on page 25

CONFigure:BURSt:CONSt:CSYMbol[:IMMediate]

This remote control command configures the result display type of window 2 to be Constellation (vs Symbol). Results are only displayed after a measurement has been executed, e.g. using the `INITiate[:IMMediate]` command.

Usage: Event

Manual operation: See "Constellation" on page 24

CONFigure:BURSt:EVM:ECARrier[:IMMediate]

This remote control command configures the result display type of window 2 to be EVM vs Carrier. Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command.

Usage: Event

Manual operation: See "EVM vs Carrier" on page 26

CONFigure:BURSt:EVM:ESYMbol[:IMMediate] (IEEE 802.11b and g (DSSS))
CONFigure:BURSt:EVM:ECHip[:IMMediate]

Both of these commands configure the measurement type to be EVM vs Chip for **IEEE 802.11b and g (DSSS)** standards. For compatibility reasons, the `CONFigure:BURSt:EVM:ESYMbol[:IMMediate]` command is also supported for the IEEE 802.11b and g (DSSS) standards. However, for new remote control programs use the `LAYout` commands (see chapter 9.7.2, "Working with Windows in the Display", on page 185).

Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command.

Manual operation: See "EVM vs Chip" on page 27

CONFigure:BURSt:EVM:ESYMbol[:IMMediate]

This remote control command configures the measurement type to be EVM vs Symbol.

For **IEEE 802.11b and g (DSSS)** standards, this command selects the EVM vs Chip result display.

Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command.

Usage: Event

Manual operation: See "EVM vs Chip" on page 27
See "EVM vs Symbol" on page 27

CONFigure:BURSt:PVT[:IMMediate]

This remote control command configures the measurement type to be Power vs Time.

CONFigure:BURSt:SPECtrum:FFT[:IMMediate]

This remote control command configures the result display type of window 2 to be FFT Spectrum. Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command.

Usage: Event

Manual operation: See "FFT Spectrum" on page 28

CONFigure:BURSt:SPECtrum:FLATness:SELect <MeasType>

This remote control command configures result display type of window 2 to be either Spectrum Flatness or Group Delay. Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command.

Parameters:
<MeasType> FLATness | GRDelay

Example: `CONF:BURS:SPEC:FLAT:SEL FLAT`
Configures the result display of window 2 to be Spectrum Flatness.
`CONF:BURS:SPEC:FLAT:IMM`
Performs a default WLAN measurement. When the measurement is completed, the Spectrum Flatness results are displayed.

Usage: Event

Manual operation: See "Group Delay" on page 29
See "Spectrum Flatness" on page 38

CONFigure:BURSt:SPECtrum:FLATness[:IMMediate]

This remote control command configures the result display in window 2 to be Spectrum Flatness or Group Delay, depending on which result display was selected last using `CONFigure:BURSt:SPECtrum:FLATness:SELect` on page 138. Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command.

Example: `CONF:BURS:SPEC:FLAT:SEL FLAT`
Configures the result display of window 2 to be Spectrum Flatness.
`CONF:BURS:SPEC:FLAT:IMM`
Performs a default WLAN measurement. When the measurement is completed, the Spectrum Flatness results are displayed.

Usage: Event

Manual operation: See "Group Delay" on page 29
See "Spectrum Flatness" on page 38

CONFigure:BURSt:STATistics:BSTReam[:IMMediate]

This remote control command configures the result display type of window 2 to be Bitstream. Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command.

Usage: Event

Manual operation: See "Bitstream" on page 22

CONFigure:BURSt:STATistics:SFIeld[:IMMediate]

This remote control command configures the result display type of window 2 to be Signal Field. Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command.

Usage: Event

Manual operation: See "PLCP Header (IEEE 802.11b, g (GSSS))" on page 30
See "Signal Field" on page 35

DISPlay[:WINDow<n>]:SELect

This command sets the focus on the selected result display window.

This window is then the active window.

Example: `DISP:WIND1:SEL`
Sets the window 1 active.

Usage: Setting only

9.4.2 Selecting a Common RF Measurement for WLAN Signals

The following commands are required to select a common RF measurement for WLAN signals in a remote environment.

For details on available measurements see chapter 3.2, "Frequency Sweep Measurements", on page 39.

The selected measurement must be started explicitely (see chapter 9.8, "Starting a Measurement", on page 193)!

CONFigure:BURSt:SPECtrum:ACPR[:IMMediate]....140
CONFigure:BURSt:SPECtrum:MASK[:IMMediate]....140
CONFigure:BURSt:SPECtrum:OBWidth[:IMMediate]....140
CONFigure:BURSt:STATistics:CCDF[:IMMediate]....140

CONFigure:BURSt:SPECtrum:ACPR[:IMMediate]

This remote control command configures the result display in window 2 to be ACPR (adjacent channel power relative). Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command.

Usage: Event

Manual operation: See "Channel Power ACLR" on page 39

CONFigure:BURSt:SPECtrum:MASK[:IMMediate]

This remote control command configures the result display in window 2 to be Spectrum Mask. Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command

Usage: Event

Manual operation: See "Spectrum Emission Mask" on page 40

CONFigure:BURSt:SPECtrum:OBWidth[:IMMediate]

This remote control command configures the result display in window 2 to be ACPR (adjacent channel power relative). Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command.

Usage: Event

Manual operation: See "Occupied Bandwidth" on page 41

CONFigure:BURSt:STATistics:CCDF[:IMMediate]

This remote control command configures the result display in window 2 to be CCDF (conditional cumulative distribution function). Results are only displayed after a measurement is executed, e.g. using the `INITiate[:IMMediate]` command.

Usage: Event

Manual operation: See "CCDF" on page 42

9.5 Configuring the WLAN IQ Measurement (Modulation Accuracy, Flatness and Tolerance)

The following commands are required to configure the WLAN IQ measurement described in chapter 3.1, "WLAN I/Q Measurement (Modulation Accuracy, Flatness and Tolerance)", on page 13.

- Signal Description....141
- Configuring the Data Input and Output....142
- Frontend Configuration....144
- Signal Capturing....151
- Synchronization and OFDM Demodulation....160
- Tracking and Channel Estimation....161
- Demodulation....163
- Evaluation Range....172
- Limits....178
- Automatic Settings....180
- Sweep Settings....183

9.5.1 Signal Description

The signal description provides information on the expected input signal.

Useful commands for describing the WLAN signal described elsewhere:

- `[SENSe:]FREQuency:CENTer` on page 145

Remote commands exclusive to describing the WLAN signal:

CONFigure:STANdard....141

CONFigure:STANdard <Standard>

This remote control command specifies which WLAN standard the option is configured to measure.

The availability of many commands depends on the selected standard!

Parameters:

<Standard> 0 | 6 | 8

0
IEEE 802.11a

6
IEEE 802.11n

8
IEEE 802.11ac

*RST: 0

Manual operation: See "Standard" on page 72

9.5.2 Configuring the Data Input and Output

- RF Input....142
- Configuring the Outputs....144

9.5.2.1 RF Input

INPut:ATTenuation:PROTection:RESet....142
INPut:COUPling....142
INPut:FILTer:HPASs[:STATe]....142
INPut:FILTer:YIG[:STATe]....143
INPut:IMPedance....143
INPut:SELect....143

INPut:ATTenuation:PROTection:RESet

This command resets the attenuator and reconnects the RF input with the input mixer after an overload condition occured and the protection mechanism intervened.The error status bit (bit 3 in the `STAT:QUES:POW` status register) and the `INPUT OVLD` message in the status bar are cleared.

The command works only if the overload condition has been eliminated first.

For details on the protection mechanism see chapter 4.6.1, "RF Input Protection", on page 61.

Usage: Event

INPut:COUPling <CouplingType>

This command selects the coupling type of the RF input.

Parameters:

<CouplingType>
AC
AC coupling
DC
DC coupling
*RST: AC

Example: `INP:COUP:DC`

Usage: SCPI confirmed

Manual operation: See "Input Coupling" on page 74

INPut:FILTer:HPASs[:STATe] <State>

Activates an additional internal high-pass filter for RF input signals from 1 GHz to 3 GHz. This filter is used to remove the harmonics of the R&S FSW in order to measure the harmonics for a DUT, for example.

This function requires option R&S FSW-B13.

(Note: for RF input signals outside the specified range, the high-pass filter has no effect. For signals with a frequency of approximately 4 GHz upwards, the harmonics are suppressed sufficiently by the YIG filter.)

Parameters:
<State> ON | OFF
*RST: OFF

Usage: SCPI confirmed

Manual operation: See "High-Pass Filter 1...3 GHz" on page 74

INPut:FILTer:YIG[:STATe] <State>

This command turns the YIG-preselector on and off.

Note the special conditions and restrictions for the YIG filter described in "YIG-Preselector" on page 74.

Parameters:
<State> ON | OFF | 0 | 1
*RST: 1 (0 for I/Q Analyzer, GSM, VSA and MC Group Delay measurements)

Example: `INP:FILT:YIG OFF`
Deactivates the YIG-preselector.

Manual operation: See "YIG-Preselector" on page 74

INPut:IMPedance <Impedance>

This command selects the nominal input impedance of the RF input.

75 Ω should be selected if the 50 Ω input impedance is transformed to a higher impedance using a matching pad of the RAZ type (= 25 Ω in series to the input impedance of the instrument). The power loss correction value in this case is 1.76 dB = 10 log (75Ω/50Ω).

Parameters:
<Impedance> 50 | 75
*RST: 50 Ω

Example: `INP:IMP 75`

Usage: SCPI confirmed

Manual operation: See "Impedance" on page 74
See "Reference Level Settings" on page 79
See "Unit" on page 80

INPut:SELect <Source>

This command selects the signal source for measurements, i.e. it defines which connector is used to input data to the R&S FSW. If no additional options are installed, only RF input is supported.

Tip: The I/Q data to be analyzed for WLAN 802.11 can not only be measured by the WLAN application itself, it can also be imported to the application, provided it has the correct format. Furthermore, the analyzed I/Q data from the WLAN application can be exported for further analysis in external applications. See chapter 5.3.13, "Import/Export Functions", on page 114.

Parameters:

<Source> **RF**
Radio Frequency ("RF INPUT" connector)
*RST: RF

Manual operation: See "Radio Frequency State" on page 74

9.5.2.2 Configuring the Outputs

Configuring trigger input/output is described in "Configuring the Trigger Output" on page 158.

DIAGnostic:SERVice:NSOurce....144

DIAGnostic:SERVice:NSOurce <State>

This command turns the 28 V supply of the BNC connector labeled NOISE SOURCE CONTROL on the front panel on and off.

For details see chapter 4.6.2, "Input from Noise Sources", on page 61.

Parameters:

<State> ON | OFF
*RST: OFF

Example: `DIAG:SERV:NSO ON`

Manual operation: See "Noise Source" on page 75

9.5.3 Frontend Configuration

The following commands configure frequency, amplitude and y-axis scaling settings, which represent the "frontend" of the measurement setup.

- Frequency....144
- Amplitude Settings....146

9.5.3.1 Frequency

[SENSe:]FREQuency:CENTer....145
[SENSe:]FREQuency:CENTer:STEP....145
[SENSe:]FREQuency:CENTer:STEP:AUTO....145
[SENSe:]FREQuency:OFFSet....146

[SENSe:]FREQuency:CENTer <Frequency>

This command defines the center frequency.

Parameters:

<Frequency> The allowed range and f_{max} is specified in the data sheet.

UP
Increases the center frequency by the step defined using the `[SENSe:]FREQuency:CENTer:STEP` command.

DOWN
Decreases the center frequency by the step defined using the `[SENSe:]FREQuency:CENTer:STEP` command.

*RST: fmax/2
Default unit: Hz

Example:

```
FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
```

Sets the center frequency to 110 MHz.

Usage: SCPI confirmed

Manual operation: See "Frequency" on page 72
See "Center" on page 77

[SENSe:]FREQuency:CENTer:STEP <StepSize>

This command defines the center frequency step size.

You can increase or decrease the center frequency quickly in fixed steps using the `SENS:FREQ UP` AND `SENS:FREQ DOWN` commands, see `[SENSe:]FREQuency:CENTer` on page 145.

Parameters:

<StepSize> f_{max} is specified in the data sheet.

Range: 1 to fMAX
*RST: 0.1 x span
Default unit: Hz

Example:

```
FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
```

Sets the center frequency to 110 MHz.

Manual operation: See "Center Frequency Stepsize" on page 77

[SENSe:]FREQuency:CENTer:STEP:AUTO <State>

This command couples or decouples the center frequency step size to the span.

Parameters:

<State> ON | OFF | 0 | 1

*RST: 1

Example: `FREQ:CENT:STEP:AUTO ON`

Activates the coupling of the step size to the span.

[SENSe:]FREQuency:OFFSet <Offset>

This command defines a frequency offset.

If this value is not 0 Hz, the application assumes that the input signal was frequency shifted outside the application. All results of type "frequency" will be corrected for this shift numerically by the application.

See also "Frequency Offset" on page 78.

Note: In MSRA mode, the setting command is only available for the MSRA Master. For MSRA applications, only the query command is available.

Parameters:

<Offset> Range: -100 GHz to 100 GHz

*RST: 0 Hz

Example: `FREQ:OFFS 1GHZ`

Usage: SCPI confirmed

Manual operation: See "Frequency Offset" on page 78

9.5.3.2 Amplitude Settings

The following commands are required to configure the amplitude settings in a remote environment.

Useful commands for amplitude settings described elsewhere:

- `INPut:COUPling` on page 142
- `INPut:IMPedance` on page 143
- `[SENSe:]ADJust:LEVel` on page 183

Remote commands exclusive to amplitude settings:

CALCulate<n>:UNIT:POWer....147
CONFigure:POWer:AUTO....147
CONFigure:POWer:EXPected:RF....147
DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:RLEVel....147
DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:RLEVel:OFFSet....148
INPut:ATTenuation....148
INPut:ATTenuation:AUTO....148
INPut:EATT....149
INPut:EATT:AUTO....149

INPut:EATT:STATe....149
INPut:GAIN[:VALue]....150
INPut:GAIN:STATe....150

CALCulate<n>:UNIT:POWer <Unit>

This command selects the unit of the y-axis.

The unit applies to all measurement windows.

Parameters:

<Unit> DBM | V | A | W | DBPW | WATT | DBUV | DBMV | VOLT | DBUA | AMPere

*RST: dBm

Example: `CALC:UNIT:POW DBM`
Sets the power unit to dBm.

Manual operation: See "Reference Level Settings" on page 79
See "Unit" on page 80

CONFigure:POWer:AUTO <Mode>

This command is used to switch on or off automatic power level detection. When switched on, power level detection is performed at the start of each measurement sweep.

Parameters:

<Mode> ON | OFF | ONCE

*RST: ON

Manual operation: See "Reference Level Settings" on page 79
See "Setting the Reference Level Automatically (Auto Level)" on page 81

CONFigure:POWer:EXPected:RF <Value>

This command specifies the mean power level of the source signal as supplied to the instrument's RF input. This value is overwritten if "Auto Level" mode is turned on.

Parameters:

<Value> Default unit: DBM

Manual operation: See "Reference Level Settings" on page 79
See "Signal Level (RMS)" on page 80

DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:RLEVel <ReferenceLevel>

This command defines the reference level.

Example: `DISP:TRAC:Y:RLEV -60dBm`

Usage: SCPI confirmed

Manual operation: See "Reference Level Settings" on page 79
See "Reference Level" on page 80

DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:RLEVel:OFFSet <Offset>

This command defines a reference level offset.

Parameters:
<Offset> Range: -200 dB to 200 dB
*RST: 0dB

Example: `DISP:TRAC:Y:RLEV:OFFS -10dB`

Manual operation: See "Reference Level Settings" on page 79
See "Shifting the Display (Offset)" on page 80

INPut:ATTenuation <Attenuation>

This command defines the total attenuation for RF input.

If an electronic attenuator is available and active, the command defines a mechanical attenuation (see `INPut:EATT:STATe` on page 149).

If you set the attenuation manually, it is no longer coupled to the reference level, but the reference level is coupled to the attenuation. Thus, if the current reference level is not compatible with an attenuation that has been set manually, the command also adjusts the reference level.

This function is not available if the Digital Baseband Interface (R&S FSW-B17) is active.

Parameters:
<Attenuation> Range: see data sheet
Increment: 5 dB
*RST: 10 dB (AUTO is set to ON)

Example: `INP:ATT 30dB`
Defines a 30 dB attenuation and decouples the attenuation from the reference level.

Usage: SCPI confirmed

Manual operation: See "RF Attenuation" on page 81
See "Attenuation Mode / Value" on page 81

INPut:ATTenuation:AUTO <State>

This command couples or decouples the attenuation to the reference level. Thus, when the reference level is changed, the R&S FSW determines the signal level for optimal internal data processing and sets the required attenuation accordingly.

Parameters:
<State> ON | OFF | 0 | 1
*RST: 1

Example: `INP:ATT:AUTO ON`
Couples the attenuation to the reference level.

Usage: SCPI confirmed

Manual operation: See "RF Attenuation" on page 81
See "Attenuation Mode / Value" on page 81

INPut:EATT <Attenuation>

This command defines an electronic attenuation manually. Automatic mode must be switched off (`INP:EATT:AUTO OFF`, see `INPut:EATT:AUTO` on page 149).

If the current reference level is not compatible with an attenuation that has been set manually, the command also adjusts the reference level.

This command is only available with option R&S FSW-B25.

It is not available if R&S FSW-B17 is active.

Parameters:
<Attenuation> attenuation in dB
Range: see data sheet
Increment: 1 dB
*RST: 0 dB (OFF)

Example:
```
INP:EATT:AUTO OFF
INP:EATT 10 dB
```

Manual operation: See "Using Electronic Attenuation (Option B25)" on page 81

INPut:EATT:AUTO <State>

This command turns automatic selection of the electronic attenuation on and off.

If on, electronic attenuation reduces the mechanical attenuation whenever possible.

This command is only available with option R&S FSW-B25.

It is not available if R&S FSW-B17 is active.

Parameters:
<State> ON | OFF | 0 | 1
*RST: 1

Example: `INP:EATT:AUTO OFF`

Manual operation: See "Using Electronic Attenuation (Option B25)" on page 81

INPut:EATT:STATe <State>

This command turns the electronic attenuator on and off.

This command is only available with option R&S FSW-B25.

It is not available if R&S FSW-B17 is active.

Parameters:

<State> ON | OFF

*RST: OFF

Example: INP:EATT:STAT ON
Switches the electronic attenuator into the signal path.

Manual operation: See "Using Electronic Attenuation (Option B25)" on page 81

INPut:GAIN[:VALue] <Gain>

This command selects the preamplification level if the preamplifier is activated (INP:GAIN:STAT ON, see INPut:GAIN:STATe on page 150).

The command requires option R&S FSW-B24.

Parameters:

<Gain> 15 dB | 30 dB

The availability of preamplification levels depends on the R&S FSW model.
- R&S FSW8: 15dB and 30 dB
- R&S FSW13: 15dB and 30 dB
- R&S FSW26: 30 dB

All other values are rounded to the nearest of these two.

*RST: OFF

Example: INP:GAIN:VAL 30
Switches on 30 dB preamplification.

Usage: SCPI confirmed

Manual operation: See "Input Settings" on page 82
See "Preamplifier (option B24)" on page 82

INPut:GAIN:STATe <State>

This command turns the preamplifier on and off.

The command requires option R&S FSW-B24.

Parameters:

<State> ON | OFF

*RST: OFF

Example: INP:GAIN:STAT ON
Switches on 30 dB preamplification.

Usage: SCPI confirmed

Manual operation: See "Input Settings" on page 82
See "Preamplifier (option B24)" on page 82

9.5.4 Signal Capturing

The following commands are required to configure how much and how data is captured from the input signal.

- General Capture Settings....151
- Configuring Triggered Measurements....152

9.5.4.1 General Capture Settings

[SENSe:]BANDwidth[:RESolution]:FILTer[:STATe]....151
[SENSe:]SWAPiq....151
[SENSe:]SWEep:TIME....152
TRACe:IQ:SRATe....152

[SENSe:]BANDwidth[:RESolution]:FILTer[:STATe] <State>

This remote control command enables or disables use of the adjacent channel filter.

If activated, only the useful signal is analyzed, all signal data in adjacent channels is removed by the filter. This setting improves the signal to noise ratio and thus the EVM results for signals with strong or a large number of adjacent channels. However, for some measurements information on the effects of adjacent channels on the measured signal may be of interest.

Parameters:

<State> ON | OFF | 0 | 1

*RST: 1

Manual operation: See "Suppressing (Filter out) Adjacent Channels (IEEE 802.11A, G (OFDM), AC, N)" on page 84

[SENSe:]SWAPiq <State>

This command defines whether or not the recorded IQ pairs should be swapped (I<->Q) before being processed. Swapping I and Q inverts the sideband.

This is useful if the DUT interchanged the I and Q parts of the signal; then the R&S FSW can do the same to compensate for it.

Parameters:

<State>

ON
I and Q signals are interchanged
Inverted sideband, Q+j*I

OFF
I and Q signals are not interchanged
Normal sideband, I+j*Q

*RST: OFF

Manual operation: See "Swap I/Q" on page 83

[SENSe:]SWEep:TIME <Time>

This command defines the sweep (or: data capture) time.

Parameters:

<Time> refer to data sheet

*RST: (AUTO is set to ON)

Example: `SWE:TIME 10s`

Usage: SCPI confirmed

Manual operation: See "Capture Time" on page 83

TRACe:IQ:SRATe <SampleRate>

This command sets the final user sample rate for the acquired I/Q data. Thus, the user sample rate can be modified without affecting the actual data capturing settings on the R&S FSW.

Note: The smaller the user sample rate, the smaller the usable I/Q bandwidth, see chapter A.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 230.

Parameters:

<SampleRate> The valid sample rates are described in chapter A.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 230.

Range: 100 Hz to 10 GHz continuously adjustable;
*RST: 32 MHz

Manual operation: See "Input Sample Rate" on page 83

9.5.4.2 Configuring Triggered Measurements

The following commands are required to configure a triggered measurement in a remote environment. The tasks for manual operation are described in chapter 5.3.5.2, "Trigger Settings", on page 84.

The `*OPC` command should be used after commands that retrieve data so that subsequent commands to change the selected trigger source are held off until after the sweep is completed and the data has been returned.

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Configuring the Triggering Conditions

TRIGger[:SEQuence]:DTIMe....153
TRIGger[:SEQuence]:HOLDoff[:TIME]....153
TRIGger[:SEQuence]:IFPower:HOLDoff....153
TRIGger[:SEQuence]:IFPower:HYSTeresis....154
TRIGger[:SEQuence]:LEVel:BBPower....154

TRIGger[:SEQuence]:LEVel[:EXTernal<port>]....154
TRIGger[:SEQuence]:LEVel:IFPower....155
TRIGger[:SEQuence]:LEVel:IQPower....155
TRIGger:SEQuence:LEVel:POWer:AUTO....155
TRIGger[:SEQuence]:LEVel:RFPower....156
TRIGger[:SEQuence]:SLOPe....156
TRIGger[:SEQuence]:SOURce....156
TRIGger[:SEQuence]:TIME:RINTerval....157

TRIGger[:SEQuence]:DTIMe <DropoutTime>

Defines the time the input signal must stay below the trigger level before a trigger is detected again.

Parameters:

<DropoutTime> Dropout time of the trigger.

Range: 0 s to 10.0 s
*RST: 0 s

Manual operation: See "Trigger Source Settings" on page 85
See "Drop-Out Time" on page 88

TRIGger[:SEQuence]:HOLDoff[:TIME] <Offset>

Defines the time offset between the trigger event and the start of the sweep (data capturing).

Parameters:

<Offset> *RST: 0 s

Example: `TRIG:HOLD 500us`

Manual operation: See "Trigger Source Settings" on page 85
See "Trigger Offset" on page 88

TRIGger[:SEQuence]:IFPower:HOLDoff <Period>

This command defines the holding time before the next trigger event.

Note that this command can be used for **any trigger source**, not just IF Power (despite the legacy keyword).

Parameters:

<Period> Range: 0 s to 10 s
*RST: 0 s

Example: `TRIG:SOUR EXT`
Sets an external trigger source.
`TRIG:IFP:HOLD 200 ns`
Sets the holding time to 200 ns.

Manual operation: See "Trigger Source Settings" on page 85
See "Trigger Holdoff" on page 89

TRIGger[:SEQuence]:IFPower:HYSTeresis <Hysteresis>

This command defines the trigger hysteresis, which is only available for "IF Power" trigger sources.

Parameters:

<Hysteresis> Range: 3 dB to 50 dB
*RST: 3 dB

Example: `TRIG:SOUR IFP`
Sets the IF power trigger source.
`TRIG:IFP:HYST 10DB`
Sets the hysteresis limit value.

Manual operation: See "Trigger Source Settings" on page 85
See "Hysteresis" on page 89

TRIGger[:SEQuence]:LEVel:BBPower <Level>

This command sets the level of the baseband power trigger.

This command is available for the **Digital Baseband Interface (R&S FSW-B17)** and the **Analog Baseband Interface (R&S FSW-B71)**.

Parameters:

<Level> Range: -50 dBm to +20 dBm
*RST: -20 DBM

Example: `TRIG:LEV:BB -30DBM`

TRIGger[:SEQuence]:LEVel[:EXTernal<port>] <TriggerLevel>

This command defines the level the external signal must exceed to cause a trigger event.

Note that the variable INPUT/OUTPUT connectors (ports 2+3) must be set for use as input using the `OUTPut:TRIGger<port>:DIRection` command.

For details on the trigger source see "Trigger Source Settings" on page 85.

Suffix:

<port> 1 | 2 | 3
Selects the trigger port.
1 = trigger port 1 (TRIGGER INPUT connector on front panel)
2 = trigger port 2 (TRIGGER INPUT/OUTPUT connector on front panel)
3 = trigger port 3 (TRIGGER3 INPUT/OUTPUT connector on rear panel)

Parameters:

<TriggerLevel> Range: 0.5 V to 3.5 V
*RST: 1.4 V

Example: `TRIG:LEV 2V`

Manual operation: See "Trigger Source Settings" on page 85
See "Trigger Level" on page 88

TRIGger[:SEQuence]:LEVel:IFPower <TriggerLevel>

This command defines the power level at the third intermediate frequency that must be exceeded to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

For details on the trigger settings see "Trigger Source Settings" on page 85.

Parameters:

<TriggerLevel> For details on available trigger levels and trigger bandwidths see the data sheet.

*RST: -10 dBm

Example: `TRIG:LEV:IFP -30DBM`

Manual operation: See "Trigger Source Settings" on page 85
See "Trigger Level" on page 88

TRIGger[:SEQuence]:LEVel:IQPower <TriggerLevel>

This command defines the magnitude the I/Q data must exceed to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed.

For details on the trigger source see "Trigger Source Settings" on page 85.

Parameters:

<TriggerLevel> Range: -130 dBm to 30 dBm
*RST: -20 dBm

Example: `TRIG:LEV:IQP -30DBM`

Manual operation: See "Trigger Source Settings" on page 85
See "Trigger Level" on page 88

TRIGger:SEQuence:LEVel:POWer:AUTO <State>

By default, the optimum trigger level for power triggers is automatically measured and determined at the start of each sweep (for Modulation Accuracy, Flatness, Tolerance... measurements).

This function is only considered for `TRIG:SEQ:SOUR IFP` and `TRIG:SEQ:SOUR RFP`, see `TRIGger[:SEQuence]:SOURce` on page 156

In order to define the trigger level manually, switch this function off and define the level using `TRIGger[:SEQuence]:LEVel:IFPower` on page 155 or `TRIGger[:SEQuence]:LEVel:RFPower` on page 156.

Parameters for setting and query:

<State>

OFF
Switches the auto level detection function off

ON
Switches the auto level detection function on

*RST: ON

Manual operation: See "Trigger Source Settings" on page 85
See "Trigger Level Mode" on page 88

TRIGger[:SEQuence]:LEVel:RFPower <TriggerLevel>

This command defines the power level the RF input must exceed to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

The input signal must be between 500 MHz and 8 GHz.

For details on the trigger source see "Trigger Source Settings" on page 85.

Parameters:

<TriggerLevel>

For details on available trigger levels and trigger bandwidths see the data sheet.

*RST: -20 dBm

Example:
```
TRIG:LEV:RFP -30dBm
```

Manual operation: See "Trigger Source Settings" on page 85
See "Trigger Level" on page 88

TRIGger[:SEQuence]:SLOPe <Type>

For all trigger sources except time you can define whether triggering occurs when the signal rises to the trigger level or falls down to it.

Parameters:

<Type>

POSitive | NEGative

POSitive
Triggers when the signal rises to the trigger level (rising edge).

NEGative
Triggers when the signal drops to the trigger level (falling edge).

*RST: POSitive

Example:
```
TRIG:SLOP NEG
```

Manual operation: See "Trigger Source Settings" on page 85
See "Slope" on page 89

TRIGger[:SEQuence]:SOURce <Source>

This command selects the trigger source.

For details on the available trigger sources see "Trigger Source Settings" on page 85.

Note on external triggers:

If a measurement is configured to wait for an external trigger signal in a remote control program, remote control is blocked until the trigger is received and the program can continue. Make sure this situation is avoided in your remote control programs.

Parameters:

<Source>

IMMediate
Free Run

EXTernal
Trigger signal from the TRIGGER INPUT connector.

EXT2
Trigger signal from the TRIGGER INPUT/OUTPUT connector.
Note: Connector must be configured for "Input".

EXT3
Trigger signal from the TRIGGER 3 INPUT/ OUTPUT connector.
Note: Connector must be configured for "Input".

RFPower
First intermediate frequency

IFPower
Second intermediate frequency

IQPower
Magnitude of sampled I/Q data
For applications that process I/Q data, such as the I/Q Analyzer or optional applications.

TIME
Time interval
(For frequency and time domain measurements only.)

PSEN
External power sensor

*RST: IMMediate

Example:

```
TRIG:SOUR EXT
```

Selects the external trigger input as source of the trigger signal

Manual operation:

See "Trigger Source Settings" on page 85
See "Trigger Source" on page 86
See "Free Run" on page 86
See "External Trigger 1/2/3" on page 86
See "IF Power" on page 86
See "I/Q Power" on page 87
See "RF Power" on page 87
See "Time" on page 87
See "Power Sensor" on page 87

TRIGger[:SEQuence]:TIME:RINTerval <Interval>

This command defines the repetition interval for the time trigger.

Parameters:

<Interval> 2.0 ms to 5000

Range: 2 ms to 5000 s
*RST: 1.0 s

Example: `TRIG:SOUR TIME`
Selects the time trigger input for triggering.
`TRIG:TIME:RINT 50`
The sweep starts every 50 s.

Manual operation: See "Trigger Source Settings" on page 85
See "Repetition Interval" on page 88

Configuring the Trigger Output

The following commands are required to send the trigger signal to one of the variable TRIGGER INPUT/OUTPUT connectors. The tasks for manual operation are described in "Trigger 2/3" on page 76.

OUTPut:TRIGger<port>:DIRection....158
OUTPut:TRIGger<port>:LEVel....158
OUTPut:TRIGger<port>:OTYPe....159
OUTPut:TRIGger<port>:PULSe:IMMediate....159
OUTPut:TRIGger<port>:PULSe:LENGth....160

OUTPut:TRIGger<port>:DIRection <Direction>

This command selects the trigger direction.

Suffix:

<port> 2 | 3
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:

<Direction> **INPut**
Port works as an input.

OUTPut
Port works as an output.

*RST: INPut

Manual operation: See "Trigger 2/3" on page 76

OUTPut:TRIGger<port>:LEVel <Level>

This command defines the level of the signal generated at the trigger output.

This command works only if you have selected a user defined output with `OUTPut:TRIGger<port>:OTYPe`.

Suffix:
<port> 2 | 3
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:
<Level> **HIGH**
TTL signal.

LOW
0 V

*RST: LOW

Manual operation: See "Trigger 2/3" on page 76
See "Output Type" on page 76
See "Level" on page 76

OUTPut:TRIGger<port>:OTYPe <OutputType>

This command selects the type of signal generated at the trigger output.

Suffix:
<port> 2 | 3
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:
<OutputType> **DEVice**
Sends a trigger signal when the R&S FSW has triggered internally.

TARMed
Sends a trigger signal when the trigger is armed and ready for an external trigger event.

UDEFined
Sends a user defined trigger signal. For more information see `OUTPut:TRIGger<port>:LEVel`.

*RST: DEVice

Manual operation: See "Trigger 2/3" on page 76
See "Output Type" on page 76

OUTPut:TRIGger<port>:PULSe:IMMediate

This command generates a pulse at the trigger output.

Suffix:
<port> 2 | 3
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Usage: Event

Manual operation: See "Trigger 2/3" on page 76
See "Output Type" on page 76
See "Send Trigger" on page 77

OUTPut:TRIGger<port>:PULSe:LENGth <Length>

This command defines the length of the pulse generated at the trigger output.

Suffix:
<port> 2 | 3
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:
<Length> Pulse length in seconds.

Manual operation: See "Trigger 2/3" on page 76
See "Output Type" on page 76
See "Pulse Length" on page 76

9.5.5 Synchronization and OFDM Demodulation

[SENSe:]DEMod:FFT:OFFSet....160
[SENSe:]DEMod:TXARea....161

[SENSe:]DEMod:FFT:OFFSet <Mode>

This command specifies the start offset of the FFT for OFDM demodulation (not for the FFT Spectrum display).

Parameters:
<Mode> AUTO | GICenter | PEAK

AUTO
The FFT start offset is automatically chosen to minimize the inter-symbol interference.

GICenter
Guard Interval Center: The FFT start offset is placed to the center of the guard interval.

PEAK
The peak of the fine timing metric is used to determine the FFT start offset.

*RST: AUTO

Manual operation: See "FFT Start Offset" on page 91

[SENSe:]DEMod:TXARea <State>

If enabled, the R&S FSW WLAN application initially performs a coarse burst search on the input signal in which increases in the power vs time trace are detected. Further time-consuming processing is then only performed where bursts are assumed. This improves the measurement speed for signals with low duty cycle rates.

However, for signals in which the PPDU power levels differ significantly, this option should be disabled as otherwise some PPDUs may not be detected.

Parameters:

<State> ON | OFF | 0 | 1

ON | 1
A coarse burst search is performed based on the power levels of the input signal.

OFF | 0
No pre-evaluation is performed, the entire signal is processed.

*RST: 1

Manual operation: See "Power Interval Search" on page 91

9.5.6 Tracking and Channel Estimation

[SENSe:]DEMod:CESTimation....161
[SENSe:]TRACking:LEVel....162
[SENSe:]TRACking:PHASe....162
[SENSe:]TRACking:PILots....162
[SENSe:]TRACking:TIME....163

[SENSe:]DEMod:CESTimation <State>

This command defines whether channel estimation will be done in preamble and payload or only in preamble. The effect of this is most noticeable for the EVM measurement results, where the results will be improved when this feature is enabled.

However, this functionality is not supported by the IEEE 802.11 standard and must be disabled if the results are to be measured strictly according to the standard.

Parameters:

<State> ON | OFF

ON
The channel estimation is performed in the preamble and the payload. The EVM results can be calculated more accurately.

OFF
The channel estimation is performed in the preamble as required in the standard.

*RST: OFF

Manual operation: See "Channel Estimation Range" on page 92

[SENSe:]TRACking:LEVel <State>

Activates or deactivates the compensation for level variations within a single PPDU. If activated, the measurement results are compensated for level error on a per-symbol basis.

Parameters:

<State> ON | OFF

*RST: OFF

Manual operation: See "Level Error (Gain) Tracking" on page 93

[SENSe:]TRACking:PHASe <State>

Activates or deactivates the compensation for phase drifts. If activated, the measurement results are compensated for phase drifts on a per-symbol basis.

Parameters:

<State> ON | OFF | 0 | 1

*RST: 1

Manual operation: See "Phase Tracking" on page 92

[SENSe:]TRACking:PILots <Mode>

In case tracking is used, the used pilot sequence has an effect on the measurement results.

Parameters:

<Mode> STANdard | DETected

STANdard
The pilot sequence is determined according to the corresponding WLAN standard. In case the pilot generation algorithm of the device under test (DUT) has a problem, the non-standard-conform pilot sequence might affect the measurement results, or the WLAN application might not synchronize at all onto the signal generated by the DUT.

DETected
The pilot sequence detected in the WLAN signal to be analyzed is used by the WLAN application. In case the pilot generation algorithm of the device under test (DUT) has a problem, the non-standard-conform pilot sequence will not affect the measurement results. In case the pilot sequence generated by the DUT is correct, it is recommended that you use the "According to Standard" setting because it generates more accurate measurement results.

*RST: STANdard

Manual operation: See "Pilots for Tracking" on page 93

[SENSe:]TRACking:TIME <State>

Activates or deactivates the compensation for timing drift. If activated, the measurement results are compensated for timing error on a per-symbol basis.

Parameters:
<State> ON | OFF
*RST: OFF

Manual operation: See "Timing Error Tracking" on page 92

9.5.7 Demodulation

The demodulation settings define which PPDUs are to be analyzed, thus they define a *logical filter*.

The available demodulation settings vary depending on the selected digital standard (see `CONFigure:STANdard` on page 141).

Manual configuration is described in chapter 5.3.8, "Demodulation", on page 93.

CONFigure:WLAN:EXTension:AUTO:TYPE....163
CONFigure:WLAN:GTIMe:AUTO....164
CONFigure:WLAN:GTIMe:AUTO:TYPE....164
CONFigure:WLAN:GTIMe:SELect....165
CONFigure:WLAN:STBC:AUTO:TYPE....166
[SENSe:]BANDwidth:CHANnel:AUTO:TYPE....166
[SENSe:]DEMod:FORMat:BANalyze....168
[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE....169
[SENSe:]DEMod:FORMat[:BCONtent]:AUTO....170
[SENSe:]DEMod:FORMat:MCSindex....170
[SENSe:]DEMod:FORMat:MCSindex:MODE....170
[SENSe:]DEMod:FORMat:NSTSindex....171
[SENSe:]DEMod:FORMat:NSTSindex:MODE....171

CONFigure:WLAN:EXTension:AUTO:TYPE <PPDUType>

Defines the PPDUs taking part in the analysis according to the Ness (Extension Spatial Streams) field content (for **IEEE 802.11n** standard only).

Parameters:

<PPDUType> FBURst | ALL | M0 | M1 | M2 | M3 | D0 | D1 | D2 | D3

The first PPDU is analyzed and subsequent PPDUs are analyzed only if they match

FBURst
The Ness field contents of the first PPDU is detected and subsequent PPDUs are analyzed only if they have the same Ness field contents (corresponds to "Auto, same type as first PPDU")

ALL
All recognized PPDUs are analyzed according to their individual Ness field contents (corresponds to "Auto, individually for each PPDU")

M0 | M1 | M2 | M3
Only PPDUs with the specified Ness value are analyzed.

D0 | D1 | D2| D3
All PPDUs are analyzed assuming the specified Ness value.

*RST: FBURst

Example: `CONF:WLAN:EXT:AUTO:TYPE M0`

Manual operation: See "Extension Spatial Streams (sounding)" on page 107

CONFigure:WLAN:GTIMe:AUTO <State>

This remote control command specifies whether the guard time of the input signal is automatically detected or specified manually (**IEEE 802.11n or ac** only).

Parameters:

<State> **ON**
The guard time is detected automatically according to `CONFigure:WLAN:GTIMe:AUTO:TYPE` on page 164.

OFF
The guard time is defined by the `CONFigure:WLAN:GTIMe:SELect` command.

*RST: ON

Manual operation: See "Guard Interval Length" on page 101

CONFigure:WLAN:GTIMe:AUTO:TYPE <Type>

This remote control command specifies which PPDUs are analyzed depending on their guard length if automatic detection is used (`CONF:WLAN:GTIM:AUTO ON`, see `CONFigure:WLAN:GTIMe:AUTO` on page 164).

This command is available for **IEEE 802.11 n, ac** standards only.

Note: On previous R&S Signal and Spectrum analyzers, this command configured both the guard interval type and the channel bandwidth. On the R&S FSW, this command only configures the guard type. The channel bandwidth of the PPDU to be measured must be configured separately using the `[SENSe:]BANDwidth:CHANnel:AUTO:TYPE` command.

Parameters:

<Type>

FBURst
The Gurad interval length of the first PPDU is detected and subsequent PPDUs are analyzed only if they have the same length (corresponds to "Auto, same type as first PPDU")

ALL
All PPDUs are analyzed regardless of their guard length (corresponds to "Auto, individually for each PPDU").

MS
Only PPDUs with short guard interval length are analyzed. (corresponds to "Meas only Short" in manual operation; MN8 | MN16 parameters in previous R&S Signal and Spectrum Analyzers)

ML
Only PPDUs with long guard interval length are analyzed. (corresponds to "Meas only Long" in manual operation; ML16 | ML32 parameters in previous R&S Signal and Spectrum Analyzers)

DS
All PPDUs are demodulated assuming short guard interval length. (corresponds to "Demod all as short" in manual operation; DN8 | DN16 parameters in previous R&S Signal and Spectrum Analyzers)

DL
All PPDUs are demodulated assuming long guard interval length. (corresponds to "Demod all as long" in manual operation; DL16 | DL32 parameters in previous R&S Signal and Spectrum Analyzers)

*RST: 'ALL'

Example: `CONF:WLAN:GTIM:AUTO:TYPE DL`

Manual operation: See "Guard Interval Length" on page 101

CONFigure:WLAN:GTIMe:SELect <GuardTime>

This remote control command specifies the guard time the PPDUs in the **IEEE 802.11n or ac** input signal should have. If the guard time is specified to be detected from the input signal using the `CONFigure:WLAN:GTIMe:AUTO` command then this command is query only and allows the detected guard time to be obtained.

Parameters:

<GuardTime> SHORt | NORMal

SHORt
Only the PPDUs with short guard interval are analyzed.

NORMal
Only the PPDUs with long guard interval are analyzed.
("Long" in manual operation)

*RST: NORMal

Example: `CONF:WLAN:GTIM:SEL SHOR`

Manual operation: See "Guard Interval Length" on page 101

CONFigure:WLAN:STBC:AUTO:TYPE <PPDUType>

This remote control command specifies which PPDUs are analyzed according to STBC streams (for **IEEE 802.11n, ac** standards only).

Parameters:

<PPDUType> FBURst | ALL | M0 | M1 | M2 | D0 | D1 | D2

FBURst
The STBC of the first PPDU is detected and subsequent PPDUs are analyzed only if they have the same STBC (corresponds to "Auto, same type as first PPDU")

ALL
All recognized PPDUs are analyzed according to their individual STBC (corresponds to "Auto, individually for each PPDU")

M0 | M1 | M2
Measure only if STBC field = 0 | 1 | 2
For details see "STBC Field" on page 99

D0 | D1 | D2
Demod all as STBC field = 0 | 1 | 2
For details see "STBC Field" on page 99

Example: `CONF:WLAN:STBC:AUTO:TYPE M0`

Manual operation: See "STBC Field" on page 99

[SENSe:]BANDwidth:CHANnel:AUTO:TYPE <Bandwidth>

This remote control command specifies the bandwidth in which the PPDUs are analyzed.

This command is only available for standards **IEEE 802.11a, ac, n**.

Note that channel bandwidths larger than 10 MHz require a R&S FSW bandwidth extension option, see chapter A.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 230.

Parameters:

<Bandwidth> FBURst | ALL | MB5 | MB10 | MB20 | MB40 | MB80 | DB20 | DB40 | DB80

FBURSt
The channel bandwidth of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same channel bandwidth (corresponds to "Auto, same type as first PPDU")

ALL
All PPDUs are analyzed regardless of the channel bandwidth (corresponds to "Auto, individually for each PPDU")

MB5
Only PPDUs within a channel bandwidth of 5MHz are analyzed (**IEEE 802.11 a only**)

MB10
Only PPDUs within a channel bandwidth of 10MHz are analyzed (**IEEE 802.11 a only**)

MB20
Only PPDUs within a channel bandwidth of 20MHz are analyzed

MB40
Only PPDUs within a channel bandwidth of 40MHz are analyzed (**IEEE 802.11 n, ac only**)

MB80
Only PPDUs within a channel bandwidth of 80MHz are analyzed (**IEEE 802.11 ac only**)

MB160
Only PPDUs within a channel bandwidth of 160MHz are analyzed (**IEEE 802.11 ac only**)

DB5
All PPDUs are analyzed within a channel bandwidth of 5MHz (**IEEE 802.11 a only**)

DB10
All PPDUs are analyzed within a channel bandwidth of 10MHz (**IEEE 802.11 a only**)

DB20
All PPDUs are analyzed within a channel bandwidth of 20MHz

DB40
All PPDUs are analyzed within a channel bandwidth of 40MHz (**IEEE 802.11 n, ac only**)

DB80
All PPDUs are analyzed within a channel bandwidth of 80MHz (**IEEE 802.11 n, ac only**)

DB160
All PPDUs are analyzed within a channel bandwidth of 160MHz (**IEEE 802.11 n, ac only**)

*RST: FBURst

Example:

```
SENS:BAND:CHAN:AUTO:TYPE MB20
```

Manual operation: See "Channel Bandwidth to measure (CBW)" on page 95

[SENSe:]DEMod:FORMat:BANalyze <Format>

Specifies which PSDUs are to be analyzed depending on their modulation. Only PSDUs using the selected modulation are considered in result analysis.

Note: to analyze all PPDUs that are identical to the first detected PPDU (corresponds to "Auto, same type as first PPDU"), use the command:
`SENS:DEMO:FORM:BANA:BTYP:AUTO:TYPE FBUR`.

To analyze all PPDUs regardless of their format and modulation (corresponds to "Auto, individually for each PPDU") , use the command:
`SENS:DEMO:FORM:BANA:BTYP:AUTO:TYPE ALL`.

See `[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 169.

Parameters:
<Format> *RST: QAM64

Example: `SENS:DEMO:FORM:BAN 'BPSK6'`

Manual operation: See "PPDU Format to measure" on page 94
See "PSDU Modulation to use" on page 95
See "PSDU Modulation" on page 96
See "PPDU Format to measure / PSDU Modulation to use" on page 102
See "PPDU Format" on page 103

Table 9-4: Modulation format parameters for IEEE 802.11a or g (OFDM) standard

SCPI parameter	Dialog parameter
BPSK6	BPSK 1/2
BPSK9	BPSK 3/4
QPSK12	QPSK 1/2
QPSK18	QPSK 3/4
QAM1624	16-QAM 1/2
QAM1636	16-QAM 3/4
QAM6448	64-QAM 2/3
QAM6454	64-QAM 3/4

Table 9-5: Modulation format parameters for IEEE 802.11b or g (DSSS) standard

SCPI parameter	Dialog parameter
CCK11	Complementary Code Keying at 11 Mbps
CCK55	Complementary Code Keying at 5.5 Mbps
DBPSK1	Differential BI-Phase shift keying
DQPSK2	Differential Quadrature phase shift keying

SCPI parameter	Dialog parameter
PBCC11	PBCC at 11 Mbps
PBCC22	PBCC at 11 Mbps
PBCC55	PBCC at 5.5 Mbps

[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE <Analysis>

This remote control command specifies how signals are analyzed.

Parameters:

<Analysis> FBURst | ALL | MMIX | MGRF | DMIX | DGRF | MVHT | DVHT | MNHT | DNHT

FBURSt
The format of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same format (corresponds to "Auto, same type as first PPDU")

ALL
All PPDUs are analyzed regardless of their format (corresponds to "Auto, individually for each PPDU")

MNHT
Only PPDUs with format "Non-HT" are analyzed
(IEEE 802.11 a)

DNHT
All PPDUs are assumed to have the PPDU format "Non-HT"
(IEEE 802.11 a)

MMIX
Only PPDUs with format "HT-MF" (Mixed) are analyzed
(IEEE 802.11 n)

MGRF
Only PPDUs with format "HT-GF" (Greenfield) are analyzed
(IEEE 802.11 n)

DMIX
All PPDUs are assumed to have the PPDU format "HT-MF"
(IEEE 802.11 n)

DGRF
All PPDUs are assumed to have the PPDU format "HT-GF"
(IEEE 802.11 n)

MVHT
Only PPDUs with format "VHT" are analyzed
(IEEE 802.11 ac)

DVHT
All PPDUs are assumed to have the PPDU format "VHT"
(IEEE 802.11 ac)

*RST: FBURSt

Example:
```
SENS:DEM:FORM:BAN:BTYP:AUTO:TYPE FBUR
```

Manual operation: See "PPDU Format to measure" on page 94
See "PSDU Modulation to use" on page 95
See "PPDU Format to measure / PSDU Modulation to use" on page 102

[SENSe:]DEMod:FORMat[:BCONtent]:AUTO <State>

This command determines whether the PPDUs to be analyzed are determined automatically or by the user.

Parameters:

<State>

ON
The signal field, i.e. the PLCP header field, of the first recognized PPDU is analyzed to determine the details of the PPDU. All PPDUs identical to the first recognized PPDU are analyzed.

OFF
Only PPDUs that match the user-defined PPDU type and modulation are considered in results analysis (see `[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 169 and `[SENSe:]DEMod:FORMat:BANalyze` on page 168).

Manual operation: See "PPDU Analysis Mode" on page 94

[SENSe:]DEMod:FORMat:MCSindex <Index>

This command specifies the MCS index which controls the data rate, modulation and streams (for **IEEE 802.11n, ac** standards only, see document: IEEE 802.11n/D11.0 June 2009).

This command is required if `[SENSe:]DEMod:FORMat:MCSindex:MODE` is set to `MEAS` or `DEM`.

Parameters:

<Index> *RST: 1

Example:
```
SENS:DEM:FORM:MCS:MODE MEAS
SENS:DEM:FORM:MCS 1
```

Manual operation: See "MCS Index" on page 99

[SENSe:]DEMod:FORMat:MCSindex:MODE <Mode>

This command defines the PPDUs taking part in the analysis depending on their Modulation and Coding Scheme (MCS) index (for **IEEE 802.11n, ac** standards only).

Parameters:

<Mode> FBURst | ALL | MEASure | DEMod

FBURst
The MCS index of the first PPDU is detected and subsequent PPDUs are analyzed only if they have the same MCS index (corresponds to "Auto, same type as first PPDU")

ALL
All recognized PPDUs are analyzed according to their individual MCS indexes (corresponds to "Auto, individually for each PPDU")

MEASure
Only PPDUs with an MCS index which matches that specified by `[SENSe:]DEMod:FORMat:MCSindex` are analyzed

DEMod
All PPDUs will be analyzed according to the MCS index specified by `[SENSe:]DEMod:FORMat:MCSindex`.

*RST: FBURst

Example:
```
SENS:DEM:FORM:MCS:MODE MEAS
SENS:DEM:FORM:MCS 1
```

Manual operation: See "MCS Index to use" on page 98

[SENSe:]DEMod:FORMat:NSTSindex <Index>

Defines the the PPDUs taking part in the analysis depending on their Nsts.

This command is only available for the **IEEE 802.11 ac** standard.

This command is available for `DEM:FORM:NSTS:MODE MEAS` or `DEM:FORM:NSTS:MODE DEM` (see `[SENSe:]DEMod:FORMat:NSTSindex:MODE` on page 171).

Parameters:

<Index>

Example:
```
SENS:DEM:FORM:NSTS:MODE MEAS
SENS:DEM:FORM:NSTS 1
```

Manual operation: See "Nsts" on page 99

[SENSe:]DEMod:FORMat:NSTSindex:MODE <Mode>

Defines the the PPDUs taking part in the analysis depending on their Nsts.

This command is only available for the **IEEE 802.11 ac** standard.

Parameters:

<Mode> FBURst | ALL | MEASure | DEMod

FBURst
The Nsts of the first PPDU is detected and subsequent PPDUs are analyzed only if they have the same Nsts (corresponds to "Auto, same type as first PPDU")

ALL
All recognized PPDUs are analyzed according to their individual Nsts (corresponds to "Auto, individually for each PPDU")

MEASure
Only PPDUs with the Nsts specified by `[SENSe:]DEMod:FORMat:NSTSindex` are analyzed

DEMod
The "Nsts" index specified by `[SENSe:]DEMod:FORMat:NSTSindex`is used for all PPDUs.

*RST: FBURst

Example:
```
SENS:DEM:FORM:NSTS:MODE MEAS
SENS:DEM:FORM:NSTS 1
```

Manual operation: See "Nsts to use" on page 99

9.5.8 Evaluation Range

The evaluation range defines which data is evaluated in the result display.

Note that, as opposed to manual operation, the PPDUs to be analyzed can be defined either by the number of data symbols, the number of data bytes, or the measurement duration.

CONFigure:BURSt:PVT:AVERage....173
CONFigure:BURSt:PVT:RPOWer....173
CONFigure:WLAN:PAYLoad:LENGth:SRC....173
CONFigure:WLAN:PVERror:MRANge?....173
[SENSe:]BURSt:COUNt....174
[SENSe:]BURSt:COUNt:STATe....174
[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal....174
[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MAX....175
[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MIN....175
[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal....175
[SENSe:]DEMod:FORMat:BANalyze:DURation:MAX....176
[SENSe:]DEMod:FORMat:BANalyze:DURation:MIN....176
[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal....177
[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MAX....177
[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MIN....177

CONFigure:BURSt:PVT:AVERage <Value>

Defines the number of samples used to adjust the length of the smoothing filter for PVT measurement.

This command is **only** available for **IEEE 802.11b, g (DSSS)** standards.

Parameters:
<Value>

Manual operation: See "PVT : Average Length (IEEE 802.11b, g (DSSS))" on page 110

CONFigure:BURSt:PVT:RPOWer <Mode>

This remote control command configures the use of either mean or maximum PPDU power as a reference power for the 802.11b, g (DSSS) PVT measurement.

Parameters:
<Mode> MEAN | MAXimum

Manual operation: See "PVT : Reference Power (IEEE 802.11b, g (DSSS))" on page 110

CONFigure:WLAN:PAYLoad:LENGth:SRC <Source>

Defines which payload length is used to determine the minimum or maximum number of required data symbols (**IEEE 802.11n, ac**).

Parameters:
<Source> ESTimate | HTSignal

ESTimate
Uses a length estimated from the input signal

HTSignal
(**IEEE811.02 n**)
Determines the length of the HT signal (from the signal field)

LSIGnal
(**IEEE811.02 ac**)
Determines the length of the L signal (from the signal field)

Manual operation: See "Source of Payload Length (IEEE 802.11 AC, N)" on page 109

CONFigure:WLAN:PVERror:MRANge? <Range>

This remote control command queries whether the Peak Vector Error results are calculated over the complete PPDU or just over the PSDU.

This command is supported for **802.11b and 802.11g (DSSS)** only.

Return values:

<Range> ALL | PSDU

ALL
Peak Vector Error results are calculated over the complete PPDU

PSDU
Peak Vector Error results are calculated over the PSDU only

Usage: Query only

Manual operation: See "Peak Vector Error : Meas Range (IEEE 802.11 B, G (DSSS))" on page 110

[SENSe:]BURSt:COUNt <Value>

If the statistic count is enabled (see `[SENSe:]BURSt:COUNt:STATe` on page 174), the specified number of PPDUs is taken into consideration for the statistical evaluation (maximally the number of PPDUs detected in the current capture buffer).

If disabled, all detected PPDUs in the current capture buffer are considered.

Parameters:

<Value> *RST: 1

Example:
```
SENS:BURS:COUN:STAT ON
SENS:BURS:COUN 10
```

Manual operation: See "PPDU Statistic Count / No of PPDUs to Analyze" on page 109

[SENSe:]BURSt:COUNt:STATe <State>

If the statistic count is enabled, the specified number of PPDUs is taken into consideration for the statistical evaluation (maximally the number of PPDUs detected in the current capture buffer).

If disabled, all detected PPDUs in the current capture buffer are considered.

Parameters:

<State> ON | OFF

*RST: OFF

Example:
```
SENS:BURS:COUN:STAT ON
SENS:BURS:COUN 10
```

Manual operation: See "PPDU Statistic Count / No of PPDUs to Analyze" on page 109

[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal <State>

For **IEEE 802.11b and g (DSSS)** signals only:

If **enabled**, only PPDUs with a **specific** payload length are considered for measurement analysis.

If **disabled**, only PPDUs whose length is within a specified **range** are considered.

The payload length is specified by the `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MIN` command.

A payload length **range** is defined as a minimum and maximum number of symbols the payload may contain (see `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MAX` on page 175 and `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MIN`).

Parameters:
<State> ON | OFF
*RST: OFF

Manual operation: See "Equal PPDU Length" on page 109

[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MAX <NumDataBytes>

If the `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal` command is set to **false**, this command specifies the maximum number of data bytes allowed for a PPDU to take part in measurement analysis.

If the `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal` command is set to **true**, then this command has no effect.

Parameters:
<NumDataBytes> *RST: 64
Default unit: bytes

Manual operation: See "(Min./Max.) Payload Length (IEEE 802.11b, g (DSSS))" on page 110

[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MIN <NumDataBytes>

For **IEEE 802.11b and g (DSSS)** signals only:

If the `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal` command is set to **true**, then this command specifies the exact number of data bytes a PPDU must have to take part in measurement analysis.

If the `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal` command is set to **false**, this command specifies the minimum number of data bytes required for a PPDU to take part in measurement analysis.

Parameters:
<NumDataBytes> *RST: 1
Default unit: bytes

Manual operation: See "(Min./Max.) Payload Length (IEEE 802.11b, g (DSSS))" on page 110

[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal <State>

For **IEEE 802.11b and g (DSSS)** signals only:

If **enabled**, only PPDUs with a **specific** duration are considered for measurement analysis.

If **disabled**, only PPDUs whose duration is within a specified **range** are considered.

The duration is specified by the `[SENSe:]DEMod:FORMat:BANalyze:DURation:MIN` command.

A duration **range** is defined as a minimum and maximum duration the PPDU may have (see `[SENSe:]DEMod:FORMat:BANalyze:DURation:MAX` and `[SENSe:]DEMod:FORMat:BANalyze:DURation:MIN`).

Parameters:
<State> ON | OFF
*RST: OFF

Manual operation: See "Equal PPDU Length" on page 109

[SENSe:]DEMod:FORMat:BANalyze:DURation:MAX <Duration>

For **IEEE 802.11b and g (DSSS)** signals only:

If the `[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal` command is set to **false**, this command specifies the maximum number of symbols allowed for a PPDU to take part in measurement analysis.

If the `[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal` command is set to **true**, then this command has no effect.

Parameters:
<Duration> *RST: 5464
Default unit: us

Manual operation: See "(Min./Max.) Payload Length (IEEE 802.11b, g (DSSS))" on page 110

[SENSe:]DEMod:FORMat:BANalyze:DURation:MIN <Duration>

For **IEEE 802.11b and g (DSSS)** signals only:

If the `[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal` command is set to **true** then this command specifies the **exact** duration required for a PPDU to take part in measurement analysis.

If the `[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal` command is set to **false** this command specifies the **minimum** duration required for a PPDU to take part in measurement analysis.

Parameters:
<Duration> *RST: 1
Default unit: us

Manual operation: See "(Min./Max.) Payload Length (IEEE 802.11b, g (DSSS))" on page 110

[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal <State>

For **IEEE 802.11a, g (OFDM), ac,n** signals only:

If **enabled**, only PPDUs with a **specific** number of symbols are considered for measurement analysis.

If **disabled**, only PPDUs whose length is within a specified **range** are considered.

The number of symbols is specified by the `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MIN` command.

A **range** of data symbols is defined as a minimum and maximum number of symbols the payload may contain (see `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MAX` on page 177 and `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MIN` on page 177).

Parameters:

<State> ON | OFF

*RST: OFF

Manual operation: See "Equal PPDU Length" on page 109

[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MAX <NumDataSymbols>

For **IEEE 802.11a, g (OFDM), ac,n** signals only:

If the `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal` command is set to **false**, this command specifies the maximum number of payload symbols allowed for a PPDU to take part in measurement analysis.

The number of payload symbols is defined as the uncoded bits including service and tail bits.

If the `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal` command has been set to **true**, then this command has no effect.

Parameters:

<NumDataSymbols> *RST: 64

[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MIN <NumDataSymbols>

For **IEEE 802.11a, g (OFDM), ac,n** signals only:

If the `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal` command has been set to **true**, then this command specifies the exact number of payload symbols a PPDU must have to take part in measurement analysis.

If the `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal` command is set to **false**, this command specifies the minimum number of payload symbols required for a PPDU to take part in measurement analysis.

The number of payload symbols is defined as the uncoded bits including service and tail bits.

Parameters:
<NumDataSymbols> *RST: 1

Example:
```
SENS:DEM:FORM:BAN:SYMB:EQU ON
SENS:DEMO:FORM:BANA:SYMB:MIN
```

Manual operation: See "(Min./Max.) No. of Data Symbols (IEEE 802.11a, g (OFDM), ac, n)" on page 109

9.5.9 Limits

The following commands are required to define the limits against which the individual parameter results are checked. Principally, the limits are defined in the WLAN 802.11 standards. However, you can change the limits for your own test cases and reset the limits to the standard values later. Note that changing limits is currently only possible via remote control, not manually via the user interface.

The commands required to retrieve the limit check results are described in chapter 9.9.1.3, "Limit Check Results", on page 203.

Useful commands for defining limits described elsewhere:

- `UNIT:EVM` on page 203
- `UNIT:GIMBalance` on page 203

Remote commands exclusive to defining limits:

CALCulate:LIMit:BURSt:ALL....178
CALCulate:LIMit:BURSt:EVM:ALL[:AVERage]....179
CALCulate:LIMit:BURSt:EVM:ALL:MAXimum....179
CALCulate:LIMit:BURSt:EVM:DATA[:AVERage]....179
CALCulate:LIMit:BURSt:EVM:DATA:MAXimum....179
CALCulate:LIMit:BURSt:EVM:PILot[:AVERage]....179
CALCulate:LIMit:BURSt:EVM:PILot:MAXimum....179
CALCulate:LIMit:BURSt:FERRor[:AVERage]....180
CALCulate:LIMit:BURSt:FERRor:MAXimum....180
CALCulate:LIMit:BURSt:IQOFfset[:AVERage]....180
CALCulate:LIMit:BURSt:IQOFfset:MAXimum....180
CALCulate:LIMit:BURSt:SYMBolerror[:AVERage]....180
CALCulate:LIMit:BURSt:SYMBolerror:MAXimum....180

CALCulate:LIMit:BURSt:ALL <Limits>

This command sets or returns the limit values for the parameters determined by the default WLAN measurement (see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13) all in one step.

To define individual limit values use the individual `CALCulate<n>:LIMit<k>:BURSt...` commands.

Note that the units for the EVM and gain imbalance parameters must be defined in advance using the following commands:

- UNIT:EVM on page 203
- UNIT:GIMBalance on page 203

Parameters:

<Limits> The parameters are input or output as a list of (ASCII) values separated by ',' in the following order:
<average CF error>, <max CF error>, <average symbol clock error>, <max symbol clock error>, <average I/Q offset>, <maximum I/Q offset>, <average EVM all carriers>, <max EVM all carriers>, <average EVM data carriers>, <max EVM data carriers> <average EVM pilots>, <max EVM pilots>

CALCulate:LIMit:BURSt:EVM:ALL[:AVERage] <Limit>
CALCulate:LIMit:BURSt:EVM:ALL:MAXimum <Limit>

This command sets or queries the average or maximum error vector magnitude limit for all carriers as determined by the default WLAN measurement.

For details on the EVM results and the default WLAN measurement see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Limit> numeric value in dB
The unit for the EVM parameters can be changed in advance using UNIT:EVM on page 203.

Default unit: DB

CALCulate:LIMit:BURSt:EVM:DATA[:AVERage] <Limit>
CALCulate:LIMit:BURSt:EVM:DATA:MAXimum <Limit>

This command sets or queries the average or maximum error vector magnitude limit for the data carrier determined by the default WLAN measurement.

For details on the EVM results and the default WLAN measurement see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Limit> numeric value in dB
The unit for the EVM parameters can be changed in advance using UNIT:EVM on page 203.

Default unit: DB

CALCulate:LIMit:BURSt:EVM:PILot[:AVERage] <Limit>
CALCulate:LIMit:BURSt:EVM:PILot:MAXimum <Limit>

This command sets or queries the maximum error vector magnitude limit for the pilot carriers determined by the default WLAN measurement.

For details on the EVM results and the default WLAN measurement see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Limit> numeric value in dB
The unit for the EVM parameters can be changed in advance using UNIT:EVM on page 203.
Default unit: DB

CALCulate:LIMit:BURSt:FERRor[:AVERage] <Limit>
CALCulate:LIMit:BURSt:FERRor:MAXimum <Limit>

This command sets or queries the average or maximum center frequency error limit determined by the default WLAN measurement.

For details on the center frequency error results and the default WLAN measurement see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Limit> numeric value in Hertz
Default unit: HZ

CALCulate:LIMit:BURSt:IQOFfset[:AVERage] <Limit>
CALCulate:LIMit:BURSt:IQOFfset:MAXimum <Limit>

This command sets or queries the average or maximum I/Q offset error limit determined by the default WLAN measurement..

For details on the I/Q offset and the default WLAN measurement see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Limit> Range: -1000000 to 1000000
Default unit: DB

CALCulate:LIMit:BURSt:SYMBolerror[:AVERage] <Limit>
CALCulate:LIMit:BURSt:SYMBolerror:MAXimum <Limit>

This command sets or queries the average or maximum symbol clock error limit determined by the default WLAN measurement.

For details on the symbol clock error and the default WLAN measurement see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Limit> numeric value in parts per million
Default unit: PPM

9.5.10 Automatic Settings

CONFigure:POWer:AUTO....181
CONFigure:POWer:AUTO:SWEep:TIME....181
[SENSe:]ADJust:CONFigure:DURation....181

[SENSe:]ADJust:CONFigure:DURation:MODE....182
[SENSe:]ADJust:CONFigure:HYSTeresis:LOWer....182
[SENSe:]ADJust:CONFigure:HYSTeresis:UPPer....183
[SENSe:]ADJust:LEVel....183

CONFigure:POWer:AUTO <State>

This command is used to switch on or off automatic level detection. When switched on, level detection is performed prior to each I/Q data capture or measurement sweep. The length of the sweep performed to determine the ideal reference level is defined by `CONFigure:POWer:AUTO:SWEep:TIME` on page 181.

Parameters for setting and query:

<State>

OFF
Switches the auto level detection function off

ON
Switches the auto level detection function on

ONCE
Performs an auto level measurement once immediately

*RST: ON

Manual operation: See "Reference Level Settings" on page 79
See "Reference Level Mode" on page 79

CONFigure:POWer:AUTO:SWEep:TIME <Value>

This command is used to specify the auto track time, i.e. the sweep time for auto level detection.

This setting can currently only be defined in remote control, not in manual operation.

Parameters for setting and query:

<Value>

numeric value

Auto level measurement sweep time

Range: 0.01 to 1
*RST: 0.1 s
Default unit: S

Example:

```
CONF:POW:AUTO:SWE:TIME 0.01 MS
```

[SENSe:]ADJust:CONFigure:DURation <Duration>

In order to determine the ideal reference level, the R&S FSW performs a measurement on the current input data. This command defines the length of the measurement if `[SENSe:]ADJust:CONFigure:DURation:MODE` is set to `MANual`.

Parameters:

<Duration> Numeric value in seconds

Range: 0.001 to 16000.0
*RST: 0.001
Default unit: s

Example: `ADJ:CONF:DUR:MODE MAN`
Selects manual definition of the measurement length.
`ADJ:CONF:LEV:DUR 5ms`
Length of the measurement is 5 ms.

Manual operation: See "Changing the Automatic Measurement Time (Meastime Manual)" on page 112

[SENSe:]ADJust:CONFigure:DURation:MODE <Mode>

In order to determine the ideal reference level, the R&S FSW performs a measurement on the current input data. This command selects the way the R&S FSW determines the length of the measurement .

Parameters:

<Mode> **AUTO**
The R&S FSW determines the measurement length automatically according to the current input data.

MANual
The R&S FSW uses the measurement length defined by `[SENSe:]ADJust:CONFigure:DURation` on page 181.

*RST: AUTO

Manual operation: See "Resetting the Automatic Measurement Time (Meastime Auto)" on page 112
See "Changing the Automatic Measurement Time (Meastime Manual)" on page 112

[SENSe:]ADJust:CONFigure:HYSTeresis:LOWer <Threshold>

When the reference level is adjusted automatically using the `[SENSe:]ADJust:LEVel` on page 183 command, the internal attenuators and the preamplifier are also adjusted. In order to avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines a lower threshold the signal must fall below (compared to the last measurement) before the reference level is adapted automatically.

Parameters:

<Threshold> Range: 0 dB to 200 dB
*RST: +1 dB
Default unit: dB

Example: `SENS:ADJ:CONF:HYST:LOW 2`
For an input signal level of currently 20 dBm, the reference level will only be adjusted when the signal level falls below 18 dBm.

Manual operation: See "Lower Level Hysteresis" on page 112

[SENSe:]ADJust:CONFigure:HYSTeresis:UPPer <Threshold>

When the reference level is adjusted automatically using the `[SENSe:]ADJust:LEVel` on page 183 command, the internal attenuators and the preamplifier are also adjusted. In order to avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines an upper threshold the signal must exceed (compared to the last measurement) before the reference level is adapted automatically.

Parameters:

<Threshold>
Range: 0 dB to 200 dB
*RST: +1 dB
Default unit: dB

Example: `SENS:ADJ:CONF:HYST:UPP 2`

Example: For an input signal level of currently 20 dBm, the reference level will only be adjusted when the signal level rises above 22 dBm.

Manual operation: See "Upper Level Hysteresis" on page 112

[SENSe:]ADJust:LEVel

This command initiates a single (internal) measurement that evaluates and sets the ideal reference level for the current input data and measurement settings. This ensures that the settings of the RF attenuation and the reference level are optimally adjusted to the signal level without overloading the R&S FSW or limiting the dynamic range by an S/N ratio that is too small.

Example: `ADJ:LEV`

Usage: Event

Manual operation: See "Setting the Reference Level Automatically (Auto Level)" on page 112

9.5.11 Sweep Settings

[SENSe:]SWEep:COUNt....183

[SENSe:]SWEep:COUNt <SweepCount>

This command defines the number of sweeps that the application uses to average traces.

In case of continuous sweeps, the application calculates the moving average over the average count.

In case of single sweep measurements, the application stops the measurement and calculates the average after the average count has been reached.

Example: `SWE:COUN 64`
Sets the number of sweeps to 64.
`INIT:CONT OFF`
Switches to single sweep mode.
`INIT;*WAI`
Starts a sweep and waits for its end.

Usage: SCPI confirmed

9.6 Configuring Frequency Sweep Measurements on WLAN Signals

The R&S FSW WLAN application uses the functionality of the FSW base system (Spectrum application, see the R&S FSW User Manual) to perform the WLAN frequency sweep measurements. The R&S FSW WLAN application automatically sets the parameters to predefined settings as described in chapter 5.4, "Frequency Sweep Measurements", on page 114.

The WLAN RF measurements must be activated for a measurement channel in the WLAN application, see chapter 9.3, "Activating WLAN Measurements", on page 132.

For details on configuring these RF measurements in a remote environment, see the Remote Commands chapter of the R&S FSW User Manual.

9.7 Configuring the Result Display

The following commands are required to configure the screen display in a remote environment. The corresponding tasks for manual operation are described in chapter 5.2, "Display Configuration", on page 68.

The suffix <n> in the following remote commands represents the window (1..16) in the currently selected measurement channel.

- General Window Commands.....184
- Working with Windows in the Display.....185
- Selecting Items to Display in Result Summary.....191

9.7.1 General Window Commands

The following commands are required to configure general window layout, independant of the application.

Note that the suffix <n> always refers to the window *in the currently selected measurement channel* (see `INSTrument[:SELect]` on page 135).

DISPlay:FORMat....185
DISPlay[:WINDow<n>]:SIZE....185

DISPlay:FORMat <Format>

This command determines which tab is displayed.

Parameters:

<Format>

SPLit
Displays the MultiView tab with an overview of all active channels

SINGle
Displays the measurement channel that was previously focused.

*RST: SPL

Example: `DISP:FORM SING`

DISPlay[:WINDow<n>]:SIZE <Size>

This command maximizes the size of the selected result display window *temporarily*. To change the size of several windows on the screen permanently, use the `LAY:SPL` command (see `LAYout:SPLitter` on page 189).

Parameters:

<Size>

LARGe
Maximizes the selected window to full screen.
Other windows are still active in the background.

SMALl
Reduces the size of the selected window to its original size.
If more than one measurement window was displayed originally, these are visible again.

*RST: SMALl

Example: `DISP:WIND2:LARG`

9.7.2 Working with Windows in the Display

The following commands are required to change the evaluation type and rearrange the screen layout for a measurement channel as you do using the SmartGrid in manual operation. Since the available evaluation types depend on the selected application, some parameters for the following commands also depend on the selected measurement channel.

Note that the suffix <n> always refers to the window *in the currently selected measurement channel* (see `INSTrument[:SELect]` on page 135).

LAYout:ADD[:WINDow]?....186
LAYout:CATalog[:WINDow]?....188
LAYout:IDENtify[:WINDow]?....188

LAYout:REMove[:WINDow]....188
LAYout:REPLace[:WINDow]....189
LAYout:SPLitter....189
LAYout:WINDow<n>:ADD?....190
LAYout:WINDow<n>:IDENtify?....191
LAYout:WINDow<n>:REMove....191
LAYout:WINDow<n>:REPLace....191

LAYout:ADD[:WINDow]? <WindowName>,<Direction>,<WindowType>

This command adds a window to the display.

This command is always used as a query so that you immediately obtain the name of the new window as a result.

To replace an existing window, use the `LAYout:REPLace[:WINDow]` command.

Parameters:

<WindowName> String containing the name of the existing window the new window is inserted next to.
By default, the name of a window is the same as its index. To determine the name and index of all active windows, use the `LAYout:CATalog[:WINDow]?` query.

<Direction> LEFT | RIGHt | ABOVe | BELow
Direction the new window is added relative to the existing window.

<WindowType> text value
Type of result display (evaluation method) you want to add.
See the table below for available parameter values.

Return values:

<NewWindowName> When adding a new window, the command returns its name (by default the same as its number) as a result.

Example:
```
LAY:ADD? '1',LEFT,MTAB
```
Result:
```
'2'
```
Adds a new window named '2' with a marker table to the left of window 1.

Usage: Query only

Manual operation:
See "Bitstream" on page 22
See "Constellation" on page 24
See "Constellation vs Carrier" on page 25
See "EVM vs Carrier" on page 26
See "EVM vs Chip" on page 27
See "EVM vs Symbol" on page 27
See "FFT Spectrum" on page 28
See "Group Delay" on page 29
See "Magnitude Capture" on page 29
See "PLCP Header (IEEE 802.11b, g (GSSS))" on page 30
See "PvT Full PPDU" on page 31
See "Result Summary Detailed" on page 32
See "Result Summary Global" on page 33
See "Signal Field" on page 35
See "Spectrum Flatness" on page 38
See "Diagram" on page 43
See "Result Summary" on page 43
See "Marker Table" on page 43
See "Marker Peak List" on page 44

Table 9-6: <WindowType> parameter values for WLAN application

Parameter value	Window type
Window types for I/Q data	
BITStream	Bitstream
CMEMory	Magnitude Capture
CONStellation	Constellation
CVCarrier	Constellation vs Carrier (**IEEE 802.11a, g (OFDM), ac,n** only)
EVCarrier	EVM vs Carrier (**IEEE 802.11a, g (OFDM), ac,n** only)
EVCHip	EVM vs Chip (**IEEE 802.11b and g (DSSS)** only)
EVSYmbol	EVM vs Symbol (**IEEE 802.11a, g (OFDM), ac,n** only)
FSPectrum	FFT Spectrum
GDELay	Group Delay (**IEEE 802.11a, g (OFDM), ac,n** only)
RSDetailed	Result Summary Detailed (**IEEE 802.11a, g (OFDM), ac,n** only)
RSGLobal	Result Summary Global
SFIeld	Signal Field (**IEEE 802.11a, g (OFDM), ac,n**) PLCP Header (**IEEE 802.11b and g (DSSS)**
SFLatness	Spectrum Flatness (**IEEE 802.11a, g (OFDM), ac,n** only)
PFPPdu	PvT Full PPDU
Window types for RF data	
DIAGram	Diagram (SEM, ACLR)
MTABle	Marker table (SEM, ACLR)

Parameter value	Window type
PEAKlist	Marker peak list (SEM, ACLR)
RSUMmary	Result summary (SEM, ACLR)

LAYout:CATalog[:WINDow]?

This command queries the name and index of all active windows from top left to bottom right. The result is a comma-separated list of values for each window, with the syntax:

<WindowName_1>,<WindowIndex_1>..<WindowName_n>,<WindowIndex_n>

Return values:

<WindowName> string
Name of the window.
In the default state, the name of the window is its index.

<WindowIndex> **numeric value**
Index of the window.

Example: `LAY:CAT?`
Result:
`'2',2,'1',1`
Two windows are displayed, named '2' (at the top or left), and '1' (at the bottom or right).

Usage: Query only

LAYout:IDENtify[:WINDow]? <WindowName>

This command queries the **index** of a particular display window.

Note: to query the **name** of a particular window, use the `LAYout:WINDow<n>:IDENtify?` query.

Query parameters:

<WindowName> String containing the name of a window.

Return values:

<WindowIndex> Index number of the window.

Usage: Query only

LAYout:REMove[:WINDow] <WindowName>

This command removes a window from the display.

Parameters:

<WindowName> String containing the name of the window.
In the default state, the name of the window is its index.

Usage: Event

LAYout:REPLace[:WINDow] <WindowName>,<WindowType>

This command replaces the window type (for example from "Diagram" to "Result Summary") of an already existing window while keeping its position, index and window name.

To add a new window, use the `LAYout:ADD[:WINDow]?` command.

Parameters:

<WindowName> String containing the name of the existing window.
By default, the name of a window is the same as its index. To determine the name and index of all active windows, use the `LAYout:CATalog[:WINDow]?` query.

<WindowType> Type of result display you want to use in the existing window.
See `LAYout:ADD[:WINDow]?` on page 186 for a list of available window types.

Example: `LAY:REPL:WIND '1',MTAB`
Replaces the result display in window 1 with a marker table.

LAYout:SPLitter <Index1>,<Index2>,<Position>

This command changes the position of a splitter and thus controls the size of the windows on each side of the splitter.

As opposed to the `DISPlay[:WINDow<n>]:SIZE` on page 185 command, the `LAYout:SPLitter` changes the size of all windows to either side of the splitter permanently, it does not just maximize a single window temporarily.

Note that windows must have a certain minimum size. If the position you define conflicts with the minimum size of any of the affected windows, the command will not work, but does not return an error.

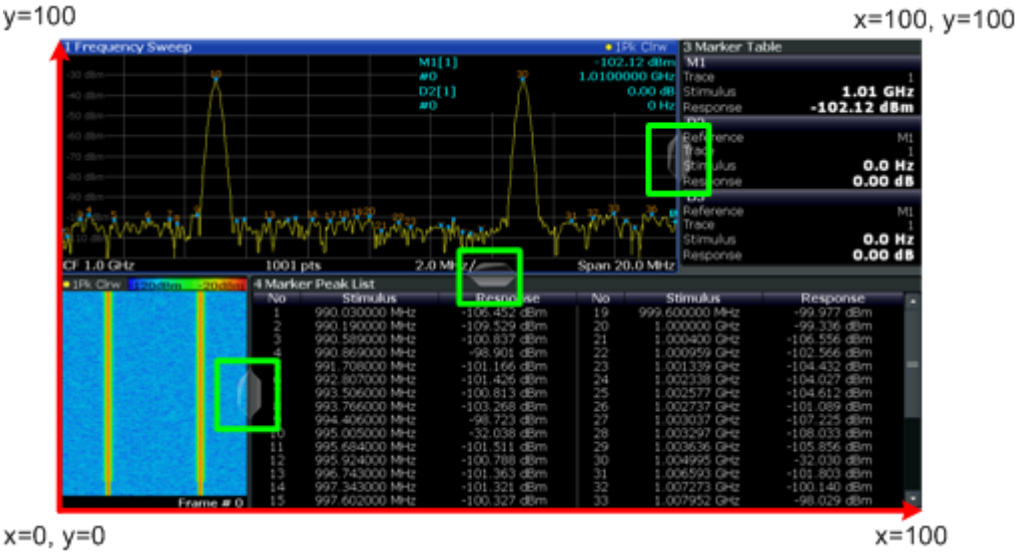

Fig. 9-1: SmartGrid coordinates for remote control of the splitters

Parameters:

<Index1> The index of one window the splitter controls.

<Index2> The index of a window on the other side of the splitter.

<Position> New vertical or horizontal position of the splitter as a fraction of the screen area (without channel and status bar and softkey menu). The point of origin (x = 0, y = 0) is in the lower left corner of the screen. The end point (x = 100, y = 100) is in the upper right corner of the screen. (See figure 9-1.)
The direction in which the splitter is moved depends on the screen layout. If the windows are positioned horizontally, the splitter also moves horizontally. If the windows are positioned vertically, the splitter also moves vertically.

Range: 0 to 100

Example: `LAY:SPL 1,3,50`
Moves the splitter between window 1 ('Frequency Sweep') and 3 ('Marker Table') to the center (50%) of the screen, i.e. in the figure above, to the left.

Example: `LAY:SPL 1,4,70`
Moves the splitter between window 1 ('Frequency Sweep') and 3 ('Marker Peak List') towards the top (70%) of the screen.
The following commands have the exact same effect, as any combination of windows above and below the splitter moves the splitter vertically.

```
LAY:SPL 3,2,70
LAY:SPL 4,1,70
LAY:SPL 2,1,70
```

LAYout:WINDow<n>:ADD? <Direction>,<WindowType>

This command adds a measurement window to the display. Note that with this command, the suffix <n> determines the existing window next to which the new window is added, as opposed to `LAYout:ADD[:WINDow]?`, for which the existing window is defined by a parameter.

To replace an existing window, use the `LAYout:WINDow<n>:REPLace` command.

This command is always used as a query so that you immediately obtain the name of the new window as a result.

Parameters:

<Direction> LEFT | RIGHt | ABOVe | BELow

<WindowType> Type of measurement window you want to add.
See `LAYout:ADD[:WINDow]?` on page 186 for a list of available window types.

Return values:

<NewWindowName> When adding a new window, the command returns its name (by default the same as its number) as a result.

Example: `LAY:WIND1:ADD? LEFT,MTAB`
Result:
`'2'`
Adds a new window named '2' with a marker table to the left of window 1.

Usage: Query only

LAYout:WINDow<n>:IDENtify?

This command queries the **name** of a particular display window (indicated by the <n> suffix).

Note: to query the **index** of a particular window, use the `LAYout:IDENtify[:WINDow]?` command.

Return values:
<WindowName> String containing the name of a window.
In the default state, the name of the window is its index.

Usage: Query only

LAYout:WINDow<n>:REMove

This command removes the window specified by the suffix <n> from the display.

The result of this command is identical to the `LAYout:REMove[:WINDow]` command.

Usage: Event

LAYout:WINDow<n>:REPLace <WindowType>

This command changes the window type of an existing window (specified by the suffix <n>).

The result of this command is identical to the `LAYout:REPLace[:WINDow]` command.

To add a new window, use the `LAYout:WINDow<n>:ADD?` command.

Parameters:
<WindowType> Type of measurement window you want to replace another one with.
See `LAYout:ADD[:WINDow]?` on page 186 for a list of available window types.

9.7.3 Selecting Items to Display in Result Summary

The following command defines which items are displayed in the Result Summary.

DISPlay[:WINDow<n>]:TABLe:ITEM <Item>,<State>

Defines which items are *displayed* in the Result Summary (see "Result Summary Detailed" on page 32 and "Result Summary Global" on page 33). Note that the results are always *calculated*, regardless of their visibility in the Result Summary.

Parameters:

<Item> Item to be included in Result Summary. For an overview of possible results and the required parameters see the tables below.

<State> ON | OFF

ON
Item is displayed in Result Summary.

OFF
Item is not displayed in Result Summary.

*RST: ON

Table 9-7: Parameters for the items of the "Result Summary Detailed"

Result in table	SCPI parameter
TX channel ("Tx All")	TALL
I/Q Offset	IOFSset
Gain imbalance	GIMBalance
Quadrature offset	QOFFset
PPDU power	TPPower
Crest factor	TCFactor
Receive channel ("Rx All")	RALL
PPDU power	RPPower
Crest factor	RCFactor
Bitstream ("Stream All")	SALL
Pilot bit error rate	BPILot
EVM all carriers	SEACarriers
EVM data carriers	SEDCarriers
EVM pilot carriers	SEPCarriers

Table 9-8: Parameters for the items of the "Result Summary Global"

Result in table	SCPI parameter
Pilot bit error rate	PBERate
EVM all carriers	EACarriers
EVM data carriers	EDCarriers
EVM pilot carriers	EPCarriers

Result in table	SCPI parameter
Center frequency error	CFERror
Symbol clock error	SCERror

9.8 Starting a Measurement

When a WLAN measurement channel is activated on the R&S FSW, a WLAN IQ measurement (Modulation Accuracy, Flatness and Tolerance, see chapter 3.1, "WLAN I/Q Measurement (Modulation Accuracy, Flatness and Tolerance)", on page 13), is started immediately. However, you can stop and start a new measurement any time.

Furthermore, you can perform a sequence of measurements using the Sequencer (see chapter 5.1, "Multiple Measurement Channels and Sequencer Function", on page 66).

ABORt....193
INITiate:CONTinuous....194
INITiate[:IMMediate]....194
INITiate:SEQuencer:ABORt....195
INITiate:SEQuencer:IMMediate....195
INITiate:SEQuencer:MODE....195
SYSTem:SEQuencer....196

ABORt

This command aborts a current measurement and resets the trigger system.

To prevent overlapping execution of the subsequent command before the measurement has been aborted successfully, use the `*OPC?` or `*WAI` command after `ABOR` and before the next command.

For details see the "Remote Basics" chapter in the R&S FSW User Manual.

To abort a sequence of measurements by the Sequencer, use the `INITiate:SEQuencer:ABORt` on page 195 command.

Note on blocked remote control programs:

If a sequential command cannot be completed, for example because a triggered sweep never receives a trigger, the remote control program will never finish and the remote channel (GPIB, LAN or other interface) to the R&S FSW is blocked for further commands. In this case, you must interrupt processing on the remote channel first in order to abort the measurement.

To do so, send a "Device Clear" command from the control instrument to the R&S FSW on a parallel channel to clear all currently active remote channels. Depending on the used interface and protocol, send the following commands:

- **Visa**: `viClear()`
- **GPIB**: `ibclr()`
- **RSIB**: `RSDLLibclr()`

Now you can send the ABORt command on the remote channel performing the measurement.

Example: ABOR;:INIT:IMM
Aborts the current measurement and immediately starts a new one.

Example: ABOR;*WAI
INIT:IMM
Aborts the current measurement and starts a new one once abortion has been completed.

Usage: SCPI confirmed

INITiate:CONTinuous <State>

This command controls the sweep mode.

Note that in single sweep mode, you can synchronize to the end of the measurement with *OPC, *OPC? or *WAI. In continuous sweep mode, synchronization to the end of the measurement is not possible. Thus, it is not recommended that you use continuous sweep mode in remote control, as results like trace data or markers are only valid after a single sweep end synchronization.

For details on synchronization see the "Remote Basics" chapter in the R&S FSW User Manual.

If the sweep mode is changed for a measurement channel while the Sequencer is active (see INITiate:SEQuencer:IMMediate on page 195) the mode is only considered the next time the measurement in that channel is activated by the Sequencer.

Parameters:

<State> ON | OFF | 0 | 1

ON | 1
Continuous sweep

OFF | 0
Single sweep

*RST: 1

Example: INIT:CONT OFF
Switches the sweep mode to single sweep.
INIT:CONT ON
Switches the sweep mode to continuous sweep.

Manual operation: See "Continuous Sweep/RUN CONT" on page 113

INITiate[:IMMediate]

This command starts a (single) new measurement.

You can synchronize to the end of the measurement with *OPC, *OPC? or *WAI.

For details on synchronization see the "Remote Basics" chapter in the R&S FSW User Manual.

Example: (For Spectrum application:)
`INIT:CONT OFF`
Switches to single sweep mode.
`DISP:WIND:TRAC:MODE AVER`
Switches on trace averaging.
`SWE:COUN 20`
Sets the sweep counter to 20 sweeps.
`INIT;*WAI`
Starts the measurement and waits for the end of the 20 sweeps.

Manual operation: See "Single Sweep/ RUN SINGLE" on page 113

INITiate:SEQuencer:ABORt

This command stops the currently active sequence of measurements. The Sequencer itself is not deactivated, so you can start a new sequence immediately using `INITiate:SEQuencer:IMMediate` on page 195.

To deactivate the Sequencer use `SYSTem:SEQuencer` on page 196.

Usage: Event

Manual operation: See "Sequencer State" on page 67

INITiate:SEQuencer:IMMediate

This command starts a new sequence of measurements by the Sequencer. Its effect is similar to the `INITiate[:IMMediate]` command used for a single measurement.

Before this command can be executed, the Sequencer must be activated (see `SYSTem:SEQuencer` on page 196).

Example:
`SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single sequence mode so each active measurement will be performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

Usage: Event

Manual operation: See "Sequencer State" on page 67

INITiate:SEQuencer:MODE <Mode>

This command selects the way the R&S FSW application performs measurements sequentially.

Before this command can be executed, the Sequencer must be activated (see SYSTem:SEQuencer on page 196).

A detailed programming example is provided in the "Operating Modes" chapter in the R&S FSW User Manual.

Note: In order to synchronize to the end of a sequential measurement using *OPC, *OPC? or *WAI you must use SINGle Sequence mode.

For details on synchronization see the "Remote Basics" chapter in the R&S FSW User Manual.

Parameters:

<Mode>

SINGle
Each measurement is performed once (regardless of the channel's sweep mode), considering each channels' sweep count, until all measurements in all active channels have been performed.

CONTinuous
The measurements in each active channel are performed one after the other, repeatedly (regardless of the channel's sweep mode), in the same order, until the Sequencer is stopped.

CDEFined
First, a single sequence is performed. Then, only those channels in continuous sweep mode (INIT:CONT ON) are repeated.

*RST: CONTinuous

Example:

SYST:SEQ ON
Activates the Sequencer.
INIT:SEQ:MODE SING
Sets single sequence mode so each active measurement will be performed once.
INIT:SEQ:IMM
Starts the sequential measurements.

Manual operation: See "Sequencer Mode" on page 67

SYSTem:SEQuencer <State>

This command turns the Sequencer on and off. The Sequencer must be active before any other Sequencer commands (INIT:SEQ...) are executed, otherwise an error will occur.

A detailed programming example is provided in the "Operating Modes" chapter in the R&S FSW User Manual.

Parameters:

<State> ON | OFF | 0 | 1

ON | 1
The Sequencer is activated and a sequential measurement is started immediately.

OFF | 0
The Sequencer is deactivated. Any running sequential measurements are stopped. Further Sequencer commands (`INIT:SEQ...`) are not available.

*RST: 0

Example:
`SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single Sequencer mode so each active measurement will be performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.
`SYST:SEQ OFF`

Manual operation: See "Sequencer State" on page 67

9.9 Retrieving Results

The following commands are required to retrieve the results from a WLAN measurement in a remote environment.

Before retrieving measurement results, check if PPDU synchronization was successful or not by checking the status register (see chapter 9.11.1, "The STATus:QUEStionable:SYNC Register", on page 224). If no PPDUs were found, `STAT:QUES:SYNC:COND?` returns 0 (see `STATus:QUEStionable:SYNC:CONDition?` on page 227).

The `*OPC` command should be used after commands that retrieve data so that subsequent commands to change the trigger or data capturing settings are held off until after the data capture is completed and the data has been returned.

- Numeric Modulation Accuracy, Flatness and Tolerance Results....198
- Numeric Results for Frequency Sweep Measurements....206
- Retrieving Trace Results....210
- Measurement Results for TRACe<n>[:DATA]? TRACE<n>....212
- Importing and Exporting I/Q Data and Results....220

9.9.1 Numeric Modulation Accuracy, Flatness and Tolerance Results

The following commands describe how to retrieve the numeric results from the standard WLAN measurements.

The commands to retrieve results from frequency sweep measurements for WLAN signals are described in chapter 9.9.2, "Numeric Results for Frequency Sweep Measurements", on page 206.

- PPDU and Symbol Count Results....198
- Error Parameter Results....199
- Limit Check Results....203

9.9.1.1 PPDU and Symbol Count Results

The following commands are required to retrieve PPDU and symbol count results from the WLAN IQ measurement on the captured I/Q data (see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13).

FETCh:BURSt:COUNt?....198
FETCh:BURSt:COUNt:ALL?....198
FETCh:SYMBol:COUNt?....198
FETCh:BURSt:LENGths?....199

FETCh:BURSt:COUNt?

This command returns the number of analyzed PPDUs from the current capture buffer. If multiple measurements are required because the number of PPDUs to analyze is greater than the number of PPDUs that can be captured in one buffer, this command only returns the number of captured PPDUs *in the current capture buffer* (as opposed to `FETCh:BURSt:COUNt:ALL?`).

Usage: Query only

FETCh:BURSt:COUNt:ALL?

This command returns the number of analyzed PPDUs for the entire measurement. If multiple measurements are required because the number of PPDUs to analyze is greater than the number of PPDUs that can be captured in one buffer, this command returns the number of analyzed PPDUs in *all* measurements (as opposed to `FETCh:BURSt:COUNt?`.

Usage: Query only

FETCh:SYMBol:COUNt?

This command returns the number of symbols in each analyzed PPDU as a comma separated list. The length of the list corresponds to the number of PPDUs, i.e. the result of `FETCh:BURSt:COUNt:ALL?`.

Usage: Query only

FETCh:BURSt:LENGths?

This command returns the length of the analyzed PPDUs from the current measurement. If the number of PPDUs to analyze is greater than the number of PPDUs that can be captured in one buffer, this command only returns the lengths of the PPDUs *in the current capture buffer*.

The result is a comma-separated list of lengths, one for each PPDU.

Return values:
<PPDULength> Length of the PPDU in symbols

Usage: Query only

9.9.1.2 Error Parameter Results

The following commands are required to retrieve individual results from the WLAN IQ measurement on the captured I/Q data (see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13).

FETCh:BURSt:ALL....200
FETCh:BURSt:CRESt[:AVERage]?....200
FETCh:BURSt:CRESt:MAXimum?....200
FETCh:BURSt:CRESt:MINimum?....200
FETCh:BURSt:EVM:ALL:AVERage?....200
FETCh:BURSt:EVM:ALL:MAXimum?....200
FETCh:BURSt:EVM:ALL:MINimum?....200
FETCh:BURSt:EVM:DATA:AVERage?....201
FETCh:BURSt:EVM:DATA:MAXimum?....201
FETCh:BURSt:EVM:DATA:MINimum?....201
FETCh:BURSt:EVM:PILot:AVERage?....201
FETCh:BURSt:EVM:PILot:MAXimum?....201
FETCh:BURSt:EVM:PILot:MINimum?....201
FETCh:BURSt:FERRor:AVERage?....201
FETCh:BURSt:FERRor:MAXimum?....201
FETCh:BURSt:FERRor:MINimum?....201
FETCh:BURSt:GIMBalance:AVERage?....201
FETCh:BURSt:GIMBalance:MAXimum?....201
FETCh:BURSt:GIMBalance:MINimum?....201
FETCh:BURSt:IQOFfset:AVERage?....202
FETCh:BURSt:IQOFfset:MAXimum?....202
FETCh:BURSt:IQOFfset:MINimum?....202
FETCh:BURSt:PAYLoad?....202
FETCh:BURSt:PEAK?....202
FETCh:BURSt:PREamble?....202
FETCh:BURSt:QUADoffset:AVERage?....202
FETCh:BURSt:QUADoffset:MAXimum?....202
FETCh:BURSt:QUADoffset:MINimum?....202
FETCh:BURSt:RMS[:AVERage]?....202

FETCh:BURSt:RMS:MAXimum?....202
FETCh:BURSt:RMS:MINimum?....202
FETCh:BURSt:SYMBolerror:AVERage....203
FETCh:BURSt:SYMBolerror:MAXimum....203
FETCh:BURSt:SYMBolerror:MINimum....203
UNIT:EVM....203
UNIT:GIMBalance....203

FETCh:BURSt:ALL

This command returns all results from the default WLAN measurement (Modulation Accuracy, Flatness and Tolerance, see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13). The results are output as a list of result strings separated by commas in ASCII format. The results are output in the following order:

Return values:

<Results> <preamble power>, <payload power>, <min rms power>,
<average rms power>, <max rms power>, <peak power>,
<min crest factor>,<average crest factor>,<max crest factor>,
<min frequency error>,<average frequency error>,
<max frequency error>, <min symbol error>,
<average symbol error>, <max symbol error>,
<min IQ offset>, <average IQ offset>, <maximum IQ offset>,
<min gain imbalance>, <average gain imbalance>,
<max gain imbalance>, <min quadrature offset>,
<average quadrature offset>, <max quadrature offset>,
<min EVM all bursts>, <average EVM all bursts>,
<max EVM all bursts>, <min EVM data carriers>,
<average EVM data carriers >, <max EVM data carriers>
<min EVM pilots>, <average EVM pilots >, <max EVM pilots>

FETCh:BURSt:CRESt[:AVERage]?
FETCh:BURSt:CRESt:MAXimum?
FETCh:BURSt:CRESt:MINimum?

This command returns the average, maximum or minimum determined CREST factor (= ratio of peak power to average power) in dB.

For details see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13

Usage: Query only

FETCh:BURSt:EVM:ALL:AVERage?
FETCh:BURSt:EVM:ALL:MAXimum?
FETCh:BURSt:EVM:ALL:MINimum?

This command returns the average, maximum or minimum EVM in dB. This is a combined figure that represents the pilot, data and the free carrier.

For details see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13

Usage: Query only

FETCh:BURSt:EVM:DATA:AVERage?
FETCh:BURSt:EVM:DATA:MAXimum?
FETCh:BURSt:EVM:DATA:MINimum?

This command returns the average, maximum or minimum EVM for the data carrier in dB.

For details see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13

Usage: Query only

FETCh:BURSt:EVM:PILot:AVERage?
FETCh:BURSt:EVM:PILot:MAXimum?
FETCh:BURSt:EVM:PILot:MINimum?

This command returns the average, maximum or minimum EVM in dB for the pilot carrier.

For details see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13

Usage: Query only

FETCh:BURSt:FERRor:AVERage?
FETCh:BURSt:FERRor:MAXimum?
FETCh:BURSt:FERRor:MINimum?

This command returns the average, maximum or minimum center frequency errors in Hertz.

For details see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13

Usage: Query only

FETCh:BURSt:GIMBalance:AVERage?
FETCh:BURSt:GIMBalance:MAXimum?
FETCh:BURSt:GIMBalance:MINimum?

This command returns the average, maximum or minimum I/Q imbalance in dB.

For details see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13

Usage: Query only

FETCh:BURSt:IQOFfset:AVERage?
FETCh:BURSt:IQOFfset:MAXimum?
FETCh:BURSt:IQOFfset:MINimum?

This command returns the average, maximum or minimum I/Q offset in dB.

For details see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13

Usage: Query only

FETCh:BURSt:PAYLoad?

This command returns the average power measured in the payload of all analyzed PPDUs.

Usage: Query only

FETCh:BURSt:PEAK?

This command returns the Peak power in dBm measured during the measurement time.

Usage: Query only

FETCh:BURSt:PREamble?

This command returns the average power measured in all analyzed PPDU preambles.

Usage: Query only

FETCh:BURSt:QUADoffset:AVERage?
FETCh:BURSt:QUADoffset:MAXimum?
FETCh:BURSt:QUADoffset:MINimum?

This command returns the average, maximum or minimum quadrature offset of symbols within a PPDU. This value indicates the phase accuracy.

For details see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Usage: Query only

FETCh:BURSt:RMS[:AVERage]?
FETCh:BURSt:RMS:MAXimum?
FETCh:BURSt:RMS:MINimum?

This command returns the average, maximum or minimum RMS power in dBm for all analyzed PPDUs.

For details see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Usage: Query only

FETCh:BURSt:SYMBolerror:AVERage
FETCh:BURSt:SYMBolerror:MAXimum
FETCh:BURSt:SYMBolerror:MINimum

This command returns the average, maximum or minimum percentage of symbols that were outside the allowed demodulation range within a PPDU.

For details see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

UNIT:EVM <Unit>

This command specifies the units for EVM limits and results (see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13).

Parameters:
<Unit> DB | PCT
*RST: DB

UNIT:GIMBalance <Unit>

This command specifies the units for gain imbalance results (see chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13).

Parameters:
<Unit> DB | PCT
*RST: DB

9.9.1.3 Limit Check Results

The following commands are required to query the results of the limit checks.

Useful commands for retrieving results described elsewhere:

- `UNIT:EVM` on page 203
- `UNIT:GIMBalance` on page 203

Remote commands exclusive to retrieving limit check results

CALCulate:LIMit:BURSt:ALL:RESult?....204
CALCulate:LIMit:BURSt:EVM:ALL[:AVERage]:RESult?....204
CALCulate:LIMit:BURSt:EVM:ALL:MAXimum:RESult?....204
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CALCulate:LIMit:BURSt:IQOFfset[:AVERage]:RESult?.....205
CALCulate:LIMit:BURSt:IQOFfset:MAXimum:RESult?.....205
CALCulate:LIMit:BURSt:SYMBolerror[:AVERage]:RESult?.....205
CALCulate:LIMit:BURSt:SYMBolerror:MAXimum:RESult?.....205

CALCulate:LIMit:BURSt:ALL:RESult?

This command returns the result of the EVM limit check for all carriers. The limit value is defined by the standard or the user (see `CALCulate:LIMit:BURSt:ALL` on page 178).

Return values:

<LimitCheck>
PASS
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate:LIMit:BURSt:EVM:ALL[:AVERage]:RESult?
CALCulate:LIMit:BURSt:EVM:ALL:MAXimum:RESult?

This command returns the result of the average or maximum EVM limit check. The limit value is defined by the standard or the user (see `CALCulate:LIMit:BURSt:EVM:ALL:MAXimum` on page 179).

Return values:

<LimitCheck>
PASS
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate:LIMit:BURSt:EVM:DATA[:AVERage]:RESult?
CALCulate:LIMit:BURSt:EVM:DATA:MAXimum:RESult?

This command returns the result of the average or maximum EVM limit check for data carriers. The limit value is defined by the standard or the user (see `CALCulate:LIMit:BURSt:EVM:DATA:MAXimum` on page 179).

Return values:

<LimitCheck>
PASS
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate:LIMit:BURSt:EVM:PILot[:AVERage]:RESult?
CALCulate:LIMit:BURSt:EVM:PILot:MAXimum:RESult?

This command returns the result of the average or maximum EVM limit check for pilot carriers. The limit value is defined by the standard or the user (see `CALCulate:LIMit:BURSt:EVM:PILot:MAXimum` on page 179).

Return values:

<LimitCheck>
PASS
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate:LIMit:BURSt:FERRor[:AVERage]:RESult?
CALCulate:LIMit:BURSt:FERRor:MAXimum:RESult?

This command returns the result of the average or maximum center frequency error limit check. The limit value is defined by the standard or the user (see `CALCulate:LIMit:BURSt:FERRor:MAXimum` on page 180).

Return values:

<LimitCheck>
PASS
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate:LIMit:BURSt:IQOFfset[:AVERage]:RESult?
CALCulate:LIMit:BURSt:IQOFfset:MAXimum:RESult?

This command returns the result of the average or maximum I/Q offset limit check. The limit value is defined by the standard or the user (see `CALCulate:LIMit:BURSt:IQOFfset:MAXimum` on page 180).

Return values:

<LimitCheck>
PASS
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate:LIMit:BURSt:SYMBolerror[:AVERage]:RESult?
CALCulate:LIMit:BURSt:SYMBolerror:MAXimum:RESult?

This command returns the result of the average or maximum symbol clock error limit check. The limit value is defined by the standard or the user (see `CALCulate:LIMit:BURSt:SYMBolerror:MAXimum` on page 180).

Return values:

<LimitCheck>

PASS
The defined limit for the parameter was not exceeded.

FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

9.9.2 Numeric Results for Frequency Sweep Measurements

The following commands are required to retrieve the numeric results of the WLAN frequency sweep measurements (see chapter 3.2, "Frequency Sweep Measurements", on page 39.

In the following commands used to retrieve the numeric results for RF data, the suffixes <n> for CALCulate and <k> for LIMit are irrelevant.

CALCulate:LIMit:ACPower:ACHannel:RESult?....206
CALCulate:LIMit:ACPower:ALTernate<ch>:RESult?....206
CALCulate:LIMit<k>:FAIL....207
CALCulate:MARKer:FUNCtion:POWer:RESult?....207
CALCulate<n>:MARKer<m>:X....209
CALCulate:STATistics:RESult<t>?....209

CALCulate:LIMit:ACPower:ACHannel:RESult?
CALCulate:LIMit:ACPower:ALTernate<ch>:RESult?

This command queries the state of the limit check for the adjacent or alternate channels in an ACLR measurement.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single sweeps. See also `INITiate:CONTinuous` on page 194.

Return values:

<LowerChan>, <UpperChan>

text value

The command returns two results. The first is the result for the lower, the second for the upper adjacent or alternate channel.

PASSED
Limit check has passed.

FAIL
Limit check has failed.

Example:

```
INIT:IMM;*WAI;
CALC:LIM:ACP:ACH:RES?
PASSED,PASSED
```

Usage: Query only

CALCulate:LIMit<k>:FAIL

This command queries the result of a limit check.

For measurements in the R&S FSW WLAN application, the numeric suffix <k> specifies the limit line according to table 9-9.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single sweeps. See also `INITiate:CONTinuous` on page 194.

Return values:

<Result>

0
PASS

1
FAIL

Example:

```
INIT;*WAI
```
Starts a new sweep and waits for its end.
```
CALC:LIM3:FAIL?
```
Queries the result of the check for limit line 3.

Usage: SCPI confirmed

Manual operation: See "Spectrum Emission Mask" on page 40

Table 9-9: Limit line suffix <k> for WLAN application

Suffix	Limit
1 to 2	These indexes are not used
3	Limit line for Spectrum Emission Mask as defined by ETSI
4	Spectrum Flatness (Upper) limit line
5	Spectrum Flatness (Lower) limit line
6	Limit line for Spectrum Emission Mask as defined by IEEE
7	PVT Rising Edge max limit
8	PVT Rising Edge mean limit
9	PVT Falling Edge max limit
10	PVT Falling Edge mean limit

CALCulate:MARKer:FUNCtion:POWer:RESult? <Measurement>

This command queries the results of power measurements.

This command is only available for measurements on RF data (see chapter 3.2, "Frequency Sweep Measurements", on page 39).

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single sweeps. See also `INITiate:CONTinuous` on page 194.

Query parameters:

<Measurement>

ACPower | MCACpower
ACLR measurements (also known as adjacent channel power or multicarrier adjacent channel measurements).
Returns the power for every active transmission and adjacent channel. The order is:
• power of the transmission channels
• power of adjacent channel (lower,upper)
• power of alternate channels (lower,upper)
MSR ACLR results:
For MSR ACLR measurements, the order of the returned results is slightly different:
• power of the transmission channels
• total power of the transmission channels for each subblock
• power of adjacent channels (lower, upper)
• power of alternate channels (lower, upper)
• power of gap channels (lower1, upper1, lower2, upper2)
The unit of the return values depends on the scaling of the y-axis:
• logarithmic scaling returns the power in the current unit
• linear scaling returns the power in W

CN
Carrier-to-noise measurements.
Returns the C/N ratio in dB.

CN0
Carrier-to-noise measurements.
Returns the C/N ratio referenced to a 1 Hz bandwidth in dBm/Hz.

CPOWer
Channel power measurements.
Returns the channel power. The unit of the return values depends on the scaling of the y-axis:
• logarithmic scaling returns the power in the current unit
• linear scaling returns the power in W
For SEM measurements, the return value is the channel power of the reference range.

PPOWer
Peak power measurements.
Returns the peak power. The unit of the return values depends on the scaling of the y-axis:
• logarithmic scaling returns the power in the current unit
• linear scaling returns the power in W
For SEM measurements, the return value is the peak power of the reference range.

OBANdwidth | OBWidth
Occupied bandwidth.
Returns the occupied bandwidth in Hz.

Usage: Query only

Manual operation: See "Channel Power ACLR" on page 39
See "Occupied Bandwidth" on page 41

CALCulate<n>:MARKer<m>:X <Position>

This command moves a marker to a particular coordinate on the x-axis.

If necessary, the command activates the marker.

If the marker has been used as a delta marker, the command turns it into a normal marker.

Parameters:

<Position> Numeric value that defines the marker position on the x-axis.
Range: The range depends on the current x-axis range.

Example: `CALC:MARK2:X 1.7MHz`
Positions marker 2 to frequency 1.7 MHz.

Manual operation: See "Marker Table" on page 43
See "Marker Peak List" on page 44

CALCulate:STATistics:RESult<t>? <ResultType>

This command queries the results of a CCDF or ADP measurement for a specific trace.

Parameters:

<ResultType>

MEAN
Average (=RMS) power in dBm measured during the measurement time.

PEAK
Peak power in dBm measured during the measurement time.

CFACtor
Determined crest factor (= ratio of peak power to average power) in dB.

ALL
Results of all three measurements mentioned before, separated by commas: <mean power>,<peak power>,<crest factor>

Example: `CALC:STAT:RES2? ALL`
Reads out the three measurement results of trace 2. Example of answer string: 5.56,19.25,13.69 i.e. mean power: 5.56 dBm, peak power 19.25 dBm, crest factor 13.69 dB

Usage: Query only

Manual operation: See "CCDF" on page 42

9.9.3 Retrieving Trace Results

The following commands describe how to retrieve the trace data from the WLAN IQ measurement (Modulation Accuracy, Flatness and Tolerance). Note that for these measurements, only 1 trace per window can be configured.

The traces for frequency sweep measurements are identical to those in the Spectrum application.

FORMat[:DATA] <Format>

This command selects the data format that is used for transmission of trace data from the R&S FSW to the controlling computer.

Note that the command has no effect for data that you send to the R&S FSW. The R&S FSW automatically recognizes the data it receives, regardless of the format.

Parameters:

<Format>

ASCii
ASCii format, separated by commas.
This format is almost always suitable, regardless of the actual data format. However, the data is not as compact as other formats may be.

REAL,32
32-bit IEEE 754 floating-point numbers in the "definite length block format".
In the Spectrum application, the format setting `REAL` is used for the binary transmission of trace data.
For I/Q data, 8 bytes per sample are returned for this format setting.

UINT
In the R&S FSW WLAN application, bitstream data can be sent as unsigned integers format to improve the data transfer speed (compared to ASCII format).

*RST: ASCII

Example: `FORM REAL,32`

Usage: SCPI confirmed

TRACe<n>[:DATA] <ResultType>

This command queries current trace data and measurement results from the window previously selected using `DISPlay[:WINDow<n>]:SELect`.

As opposed to the R&S FSW base unit, the window suffix <n> is not considered in the R&S FSW WLAN application! Use the `DISPlay[:WINDow<n>]:SELect` to select the window before you query trace results!

For details see chapter 9.9.4, "Measurement Results for TRACe<n>[:DATA]? TRACE<n>", on page 212.

Suffix:
<n> irrelevant

Parameters:
<ResultType> Selects the type of result to be returned.

TRACE1 | ... | TRACE6
Returns the trace data for the corresponding trace.
Note that for the default WLAN I/Q measurement (Modulation Accuracy, Flatness and Tolerance), only 1 trace per window (TRACE1) is available.

LIST
Returns the results of the peak list evaluation for Spectrum Emission Mask measurements.

Return values:
<TraceData> For more information see tables below.

Example:
```
DISP:WIND2:SEL
TRAC? TRACE3
```
Queries the data of trace 3 in window 2.

Manual operation: See "Spectrum Emission Mask" on page 40

Table 9-10: Return values for TRACE1 to TRACE6 parameter

For I/Q data traces, the results depend on the evaluation method (window type) selected for the current window (see `LAYout:ADD[:WINDow]?` on page 186. The results for the various window types are described in chapter 9.9.4, "Measurement Results for TRACe<n>[:DATA]? TRACE<n>", on page 212.

For RF data traces, the trace data consists of a list of 1001 power levels that have been measured. The unit depends on the measurement and on the unit you have currently set.

For SEM measurements, the x-values should be queried as well, as they are not equi-distant (see `TRACe<n>[:DATA]:X?` on page 212).

Table 9-11: Return values for LIST parameter

This parameter is only available for SEM measurements.

For each sweep list range you have defined (range 1...n), the command returns eight values in the following order.

<No>,<StartFreq>,<StopFreq>,<RBW>,<PeakFreq>,<PowerAbs>,<PowerRel>,<PowerDelta>,<LimitCheck>,<Unused1>,<Unused2>

- <No>: range number
- <StartFreq>,<StopFreq>: start and stop frequency of the range
- <RBW>: resolution bandwidth
- <PeakFreq>: frequency of the peak in a range
- <PowerAbs>: absolute power of the peak in dBm
- <PowerRel>: power of the peak in relation to the channel power in dBc
- <PowerDelta>: distance from the peak to the limit line in dB, positive values indicate a failed limit check
- <LimitCheck>: state of the limit check (0 = PASS, 1 = FAIL)
- <Unused1>,<Unused2>: reserved (0.0)

TRACe<n>[:DATA]:X? <TraceNumber>

This command queries the horizontal trace data for each sweep point in the specified window, for example the frequency in frequency domain or the time in time domain measurements. This is especially useful for traces with non-equidistant x-values, e.g. for SEM or Spurious Emissions measurements.

Query parameters:

<TraceNumber> Trace number.

TRACE1 | ... | TRACE6

Example: `TRAC3:X? TRACE1`
Returns the x-values for trace 1 in window 3.

Usage: Query only

TRACe:IQ:DATA:MEMory <OffsetSamp>, <NumSamples>

Returns all the I/Q trace data in the capture buffer. The result values are scaled in Volts. The command returns a comma-separated list of the measured voltage values in floating point format (Comma Separated Values = CSV). The number of values returned is 2 * the number of complex samples, the first half being the I values, the second half the Q values.

The total number of complex samples is displayed in the channel bar in manual operation and can be calculated as:

<SampleRate> * <CaptureTime>

(See `TRACe:IQ:SRATe` on page 152 and `[SENSe:]SWEep:TIME` on page 152)

Parameters:

<OffsetSamp> Offset of the values to be read related to the start of the capture buffer.

Range: 0 to (<NumSamples>-1)

<NumSamples> Number of measurement values to be read.

Range: 1 to (<NumSamples>-<OffsetSa>)
*RST: RST value

9.9.4 Measurement Results for TRACe<n>[:DATA]? TRACE<n>

The evaluation method selected by the `LAY:ADD:WIND` command also affects the results of the trace data query (see TRACe<n>[:DATA]? TRACE<n>).

Details on the returned trace data depending on the evaluation method are provided here.

No trace data is available for the following evaluation methods:

- Magnitude Capture
- Result Summary (Global/Detailed)

As opposed to the R&S FSW base unit, the window suffix <n> is not considered in the R&S FSW WLAN application! Use the `DISPlay[:WINDow<n>]:SELect` to select the window before you query trace results!

For details on the graphical results of these evaluation methods, see chapter 3.1.2, "Evaluation Methods for WLAN IQ Measurements", on page 21.

The following table provides an overview of the main characteristics of the WLAN OFDM symbol structure in the frequency domain for various standards. The description of the TRACe results refers to these values to simplify the description.

Table 9-12: WLAN OFDM symbol structure in the frequency domain

Standard	CBW / MHz	N_{FFT}	N_{SD} No. of data sc	N_{SP} No. of pilot sc	Pilot subcarrier (sc)	N_{ST} No. of sc total : $=N_{SD}+N_{SP}$	N_{Null} No. of DC/ Null sc	DC / Null subcarrier	N_{used} No. of used sc := $N_{ST}+N_{Null}$	N_{guard} :=N_{FFT} -N_{used}	Comment
11a	5	64	48	4	{-21,-7,7,21}	52	1	{0}	53	11	IEEE Std 802.11-2012 Tab Table 18-5—Timing-related parameters
	10	64	48	4	{-21,-7,7,21}	52	1	{0}	53	11	IEEE Std 802.11-2012 Tab Table 18-5—Timing-related parameters
	20	64	48	4	{-21,-7,7,21}	52	1	{0}	53	11	IEEE Std 802.11-2012 Tab Table 18-5—Timing-related parameters
11n	20	64	52	4	{-21,-7,7,21}[1)]	56	1	{0}	57	7	IEEE Std 802.11-2012 Tab Table 20-6—Timing-related constants
	40	128	108	6	{-53, -25, -11, 11, 25, 53}[1)]	114	3	{-1,0,1}[3)]	117	11	IEEE Std 802.11-2012 Tab Table 20-6—Timing-related constants
11ac	20	64	52	4	{-21,-7,7,21}2	56	1	{0}	57	7	IEEE P802.11ac/D2.1, March 2012 Table 22-5—Timing-related constants
	40	128	108	6	{-53, -25, -11, 11, 25, 53}[2)]	114	3	{-1,0,1}[4)]	117	11	IEEE P802.11ac/D2.1, March 2012 Table 22-5—Timing-related constants

1) IEEE Std 802.11-2012 Section 20.3.11.10 Pilot subcarriers

2) IEEE P802.11ac/D2.1, March 2012 Section 22.3.10.10 Pilot subcarriers

3) IEEE Std 802.11-2012 equation (20-59)

4) IEEE P802.11ac/D2.1, March 2012 equation (22-94)

5) IEEE P802.11ac/D2.1, March 2012 equation (22-95)

6) IEEE P802.11ac/D2.1, March 2012 equation (22-96)

Standard	CBW / MHz	N_{FFT}	N_{SD} No. of data sc	N_{SP} No. of pilot sc	Pilot subcarrier (sc)	N_{ST} No. of sc total : $=N_{SD}+N_{SP}$	N_{Null} No. of DC/ Null sc	DC / Null subcarrier	N_{used} No. of used sc := $N_{ST}+N_{Null}$	N_{guard} :=N_{FFT} -N_{used}	Comment
	80	256	234	8	{–103, –75, –39, –11, 11, 39, 75,103}[2]	242	3	{-1,0,1}[5]	245	11	IEEE P802.11ac/D2.1, March 2012 Table 22-5—Timing-related constants
	160	512	468	16	{ -231, -203, -167, -139, -117, -89, -53, -25, 25, 53, 89, 117, 139, 167, 203, 231}[2]	484	17	{-129, -128, -127, -5:1:5, 127, 128, 129}[6]	501	11	IEEE P802.11ac/D2.1, March 2012 Table 22-5—Timing-related constants

1) IEEE Std 802.11-2012 Section 20.3.11.10 Pilot subcarriers

2) IEEE P802.11ac/D2.1, March 2012 Section 22.3.10.10 Pilot subcarriers

3) IEEE Std 802.11-2012 equation (20-59)

4) IEEE P802.11ac/D2.1, March 2012 equation (22-94)

5) IEEE P802.11ac/D2.1, March 2012 equation (22-95)

6) IEEE P802.11ac/D2.1, March 2012 equation (22-96)

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9.9.4.1 Bitstream

Data is returned depending on the selected standard for which the measurement was executed (see `CONFigure:STANdard` on page 141):

- For the IEEE 802.11a and n standard, data is returned in repeating groups of 52 data channels (or 56 channels within the n standard) where each symbol value is represented by an integer value within one byte. Channel 0 is unused and therefore does not have any data associated with it, with no return data being provided.

Supported data formats: `ASCii|UINT` (see `FORMat[:DATA]` on page 210)

9.9.4.2 CCDF – Complementary Cumulative Distribution Function

The length of the results varies; up to a maximum of 201 data points is returned, following a data count value. The first value in the return data represents the quantity of probability values that follow. Each of the potential 201 data points is returned as a probability value and represents the total number of samples that are equal to or exceed the current mean power level.

Probability data is returned up to the power level that contains at least one sample. It is highly unlikely that the full 201 data values will ever be returned.

Each probability value is returned as a floating point number, with a value between 0 and 1.

The syntax of the result is thus:

N, CCDF(0), CCDF(1/10), CCDF(2/10), …, CCDF((N-1)/10)

9.9.4.3 Constellation

This measurement represents the complex constellation points as I and Q data. See for example IEEE Std. 802.11-2012 'Fig. 18-10 BPSK, QPSK, 16-QAM and 64-QAM constellation bit encoding'. Each I and Q point is returned in floating point format.

Data is returned as a repeating array of interleaved I and Q data in groups of selected carriers per OFDM-Symbol, until all the I and Q data for the analyzed OFDM-Symbols is exhausted.

The following carrier selections are possible:

- "All Carriers": `CONFigure:BURSt:CONStellation:CARRier:SELect ALL`
  N_{ST} pairs of I and Q data per OFDM-Symbol
  OFDM-Symbol 1: $(I_{1,1}, Q_{1,1}), (I_{1,2},Q_{1,2}), \ldots,(I_{1,Nst}, Q_{1,Nst})$
  OFDM-Symbol 2: $(I_{2,1}, Q_{2,1}), (I_{2,2},Q_{2,2}),\ldots,(I_{2,Nst}, Q_{2,Nst})$
  …
  OFDM-Symbol N:
  $(I_{N,1}, Q_{N,1}), (I_{N,2},Q_{N,2}),\ldots,(I_{N,Nst}, Q_{N,Nst})$
- "Pilots Only": `CONFigure:BURSt:CONStellation:CARRier:SELect PILOTS`
  N_{SP} pairs of I and Q data per OFDM-Symbol in the natural number order.
  OFDM-Symbol 1: $(I_{1,1}, Q_{1,1}), (I_{1,2},Q_{1,2}), \ldots,(I_{1,Nsp}, Q_{1,Nsp})$
  OFDM-Symbol 2: $(I_{2,1}, Q_{2,1}), (I_{2,2},Q_{2,2}),\ldots,(I_{2,Nsp}, Q_{2,Nsp})$
  …
  OFDM-Symbol N:
  $(I_{N,1}, Q_{N,1}), (I_{N,2},Q_{N,2}),\ldots,(I_{N,Nsp}, Q_{N,Nsp})$
- Single carrier:
  1 pair of I and Q data per OFDM-Symbol for the selected carrier
  `CONFigure:BURSt:CONStellation:CARRier:SELect k`
  with
  $$k \in \{-(N_{used}-1)/2, -(N_{used}-1)/2+1, \ldots, (N_{used}-1)/2\}$$
  OFDM-Symbol 1: $(I_{1,1}, Q_{1,1})$
  OFDM-Symbol 2: $(I_{2,1}, Q_{2,1})$
  …
  OFDM-Symbol N: $(I_{N,1}, Q_{N,1})$

9.9.4.4 Constellation vs Carrier

This measurement represents the complex constellation points as I and Q data. See for example IEEE Std. 802.11-2012 'Fig. 18-10 BPSK, QPSK, 16-QAM and 64-QAM constellation bit encoding'. Each I and Q point is returned in floating point format. Data is returned as a repeating array of interleaved I and Q data in groups of N_{used} subcarriers per OFDM-Symbol, until all the I and Q data for the analyzed OFDM-Symbols is exhausted.

Note that as opposed to the Constellation results, the DC/null subcarriers are included as NaNs.

N_{used} pairs of I and Q data per OFDM-Symbol

OFDM-Symbol 1: $(I_{1,1}, Q_{1,1}), (I_{1,2},Q_{1,2}), \ldots,(I_{1,Nused}, Q_{1,Nused})$

OFDM-Symbol 2: $(I_{2,1}, Q_{2,1}), (I_{2,2},Q_{2,2}),\ldots,(I_{2,Nused}, Q_{2,Nused})$

…

OFDM-Symbol N:

$(I_{N,1}, Q_{N,1}), (I_{N,2},Q_{N,2}),\ldots,(I_{N,Nused}, Q_{N,Nused})$

9.9.4.5 EVM vs Carrier

Three trace types are provided for this evaluation:

Table 9-13: Query parameter and results for EVM vs Carrier

TRACE1	The minimum EVM value - over the analyzed PPDUs - for each of the N_{used} subcarriers
TRACE2	The average EVM value - over the analyzed PPDUs - for each of the N_{used} subcarriers
TRACE3	The maximum EVM value - over the analyzed PPDUs - for each of the N_{used} subcarriers

Each EVM value is returned as a floating point number, expressed in units of dB.

Supported data formats (see `FORMat[:DATA]` on page 210): `ASCii|UINT`

Example:

For $EVM_{m,n}$: the EVM of the m-th analyzed PPDU for the subcarrier n = {1,2,…, N_{used} }

TRACE1: Minimum EVM value per subcarrier

Minimum($EVM_{1,1}$, $EVM_{2,1}$,…. $EVM_{Statistic\ Length,1}$),

//Minimum EVM value for subcarrier –(N_{used}-1)/2

Minimum($EVM_{1,2}$, $EVM_{2,2}$,…. $EVM_{Statistic\ Length,2}$),

// Minimum EVM value for subcarrier –(N_{used}-1)/2 + 1

…,

Minimum($EVM_{1,Nused}$,$EVM_{2,Nused}$,…. $EVM_{Statistic\ Length,Nused}$)

// Minimum EVM value for subcarrier +(N_{used}-1)/2

9.9.4.6 FFT Spectrum

Returns the power vs frequency values obtained from the FFT. This is an exhaustive call, due to the fact that there are nearly always more FFT points than I/Q samples. The number of FFT points is a power of 2 that is higher than the total number of I/Q samples, i.e.; number of FFT points := round number of I/Q-samples to next power of 2.

E.g. if there were 20000 samples, then 32768 FFT points are returned.

Data is returned in floating point format in dBm.

9.9.4.7 Group Delay

Currently the following trace types are provided with this measurement:

- `TRACE1`
  A repeating list of group delay values for each subcarrier. The number of repeating lists corresponds to the number of fully analyzed PPDUs as displayed in the current Magnitude Capture. Each group delay value is returned as a floating point number, expressed in units of seconds.
- `TRACE`
  All group delay values per subcarrier for each analyzed PPDU of the capture period

Example:

For $GD_{m,n}$: the group delay of the m-th analyzed PPDU for the subcarrier corresponding to n = {1,2,…, N_{used} };

```
TRACE:DATA? TRACE2
```

Analyzed PPDU 1:

$GD_{1,1}$, $GD_{1,2}$, …,

Analyzed PPDU 2:

$GD_{2,1}$, $GD_{2,2}$, …,

…

Analyzed PPDU N :

$GD_{N,1}$, $GD_{N,2}$, …,

9.9.4.8 Power vs Time Full Burst

All complete PPDUs within the capture time are analyzed in three master PPDUs. The three master PPDUs relate to the minimum, maximum and average values across all complete PPDUs. This data is returned in dBm values on a per sample basis. Each sample relates to an analysis of each corresponding sample within each processed PPDU.

The type of PVT data returned is determined by the TRACE number passed as an argument to the SCPI command:

TRACE1	minimum PPDU data values
TRACE2	mean PPDU data values
TRACE3	maximum PPDU data values

Supported data formats (see `FORMat[:DATA]` on page 210): `ASCii|REAL`

9.9.4.9 Signal Field

The bits are returned as read from the corresponding signal field parts in transmit order. I.e. the first transmitted bit has the highest significance and the last transmitted bit has the lowest significance. See also "Signal Field" on page 35.

The `TRAC:DATA?` command returns the information as read from the signal field for each analyzed PPDU. The signal field bit sequence is converted to an equivalent sequence of hexadecimal digits for each analyzed PPDU in transmit order.

9.9.4.10 Spectrum Flatness

The spectrum flatness evaluation returns absolute power values per carrier.

Two trace types are provided for this evaluation:

Table 9-14: Query parameter and results for Spectrum Flatness

TRACE1	All spectrum flatness values per channel
TRACE2	An average spectrum flatness value for each of the 53 (or 57/117 within the IEEE 802.11 n standard) carriers

Absolute power results are returned in dB.

Supported data formats (FORMat:DATA): ASCii|REAL

9.9.5 Importing and Exporting I/Q Data and Results

The I/Q data to be evaluated in the WLAN application can not only be measured by the WLAN application itself, it can also be imported to the application, provided it has the correct format. Furthermore, the evaluated I/Q data from the WLAN application can be exported for further analysis in external applications.

For details on importing and exporting I/Q data see the R&S FSW User Manual.

MMEMory:LOAD:IQ:STATe.....220
MMEMory:STORe:IQ:STATe.....220

MMEMory:LOAD:IQ:STATe 1,<FileName>

This command restores I/Q data from a file.

The file extension is *.iqw.

Parameters:

<FileName> String containing the path and name of the source file.

Example: `MMEM:LOAD:IQ:STAT 1, 'C:\R_S\Instr\user\data.iqw'`
Loads IQ data from the specified file.

Usage: Setting only

Manual operation: See "Import" on page 114
See "IQ Import" on page 114

MMEMory:STORe:IQ:STATe 1, <FileName>

This command writes the captured I/Q data to a file.

The file extension is *.iq.tar. By default, the contents of the file are in 32-bit floating point format.

Parameters:

1

<FileName> String containing the path and name of the target file.

Example: `MMEM:STOR:IQ:STAT 1, 'C:\R_S\Instr\user\data.iq.tar'`
Stores the captured I/Q data to the specified file.

Manual operation: See "Export" on page 114
See "IQ Export" on page 114

9.10 Analysis

The following commands define general result analysis settings concerning the traces and markers in standard WLAN measurements. Currently, only one (Clear/Write) trace and one marker are available for standard WLAN measurements.

Analysis for RF measurements

General result analysis settings concerning the trace, markers, lines etc. are identical to the analysis functions in the Spectrum application except for some special marker functions and spectrograms, which are not available in the WLAN application.

For details see the "General Measurement Analysis and Display" chapter in the R&S FSW User Manual.

- Markers....221
- Zooming into the Display....222

9.10.1 Markers

Markers help you analyze your measurement results by determining particular values in the diagram. Currently, only 1 marker per window can be configured for standard WLAN measurements.

CALCulate<n>:MARKer<m>[:STATe]....221
CALCulate<n>:MARKer<m>:Y?....221

CALCulate<n>:MARKer<m>[:STATe] <State>

This command turns markers on and off. If the corresponding marker number is currently active as a deltamarker, it is turned into a normal marker.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `CALC:MARK3 ON`
Switches on marker 3.

CALCulate<n>:MARKer<m>:Y?

This command queries the position of a marker on the y-axis.

If necessary, the command activates the marker first.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single sweeps. See also `INITiate:CONTinuous` on page 194.

Return values:

<Result> Result at the marker position.

Example:

```
INIT:CONT OFF
```
Switches to single measurement mode.
```
CALC:MARK2 ON
```
Switches marker 2.
```
INIT;*WAI
```
Starts a measurement and waits for the end.
```
CALC:MARK2:Y?
```
Outputs the measured value of marker 2.

Usage: Query only

Manual operation: See "CCDF" on page 42
See "Marker Table" on page 43
See "Marker Peak List" on page 44

9.10.2 Zooming into the Display

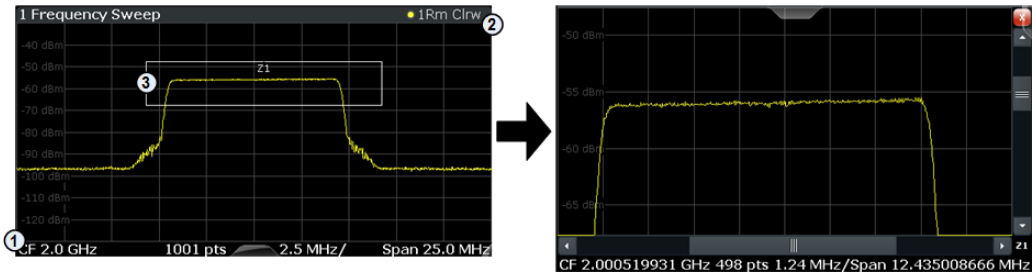
9.10.2.1 Using the Single Zoom

DISPlay[:WINDow<n>]:ZOOM:AREA....222
DISPlay[:WINDow<n>]:ZOOM:STATe....223

DISPlay[:WINDow<n>]:ZOOM:AREA <x1>,<y1>,<x2>,<y2>

This command defines the zoom area.

To define a zoom area, you first have to turn the zoom on.



1 = origin of coordinate system (x1 = 0, y1 = 0)
2 = end point of system (x2 = 100, y2= 100)
3 = zoom area (e.g. x1 = 60, y1 = 30, x2 = 80, y2 = 75)

Parameters:

<x1>,<y1>, <x2>,<y2>
Diagram coordinates in % of the complete diagram that define the zoom area.
The lower left corner is the origin of coordinate system. The upper right corner is the end point of the system.

Range: 0 to 100
Default unit: PCT

DISPlay[:WINDow<n>]:ZOOM:STATe <State>

This command turns the zoom on and off.

Parameters:

<State>
ON | OFF

*RST: OFF

Example:
```
DISP:ZOOM ON
```
Activates the zoom mode.

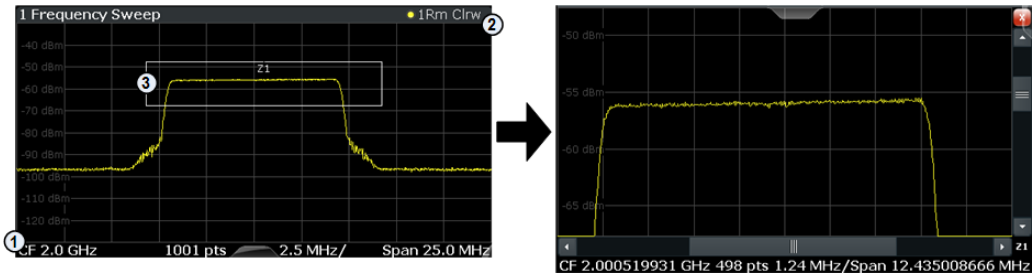
9.10.2.2 Using the Multiple Zoom

DISPlay[:WINDow<n>]:ZOOM:MULTiple<zoom>:AREA....223
DISPlay[:WINDow<n>]:ZOOM:MULTiple<zoom>:STATe....224

DISPlay[:WINDow<n>]:ZOOM:MULTiple<zoom>:AREA <x1>,<y1>,<x2>,<y2>

This command defines the zoom area for a multiple zoom.

To define a zoom area, you first have to turn the zoom on.



1 = origin of coordinate system (x1 = 0, y1 = 0)
2 = end point of system (x2 = 100, y2= 100)
3 = zoom area (e.g. x1 = 60, y1 = 30, x2 = 80, y2 = 75)

Suffix:

<zoom>
1...4
Selects the zoom window.

Parameters:

<x1>,<y1>, <x2>,<y2>
Diagram coordinates in % of the complete diagram that define the zoom area.
The lower left corner is the origin of coordinate system. The upper right corner is the end point of the system.

Range: 0 to 100
Default unit: PCT

DISPlay[:WINDow<n>]:ZOOM:MULTiple<zoom>:STATe <State>

This command turns the mutliple zoom on and off.

Suffix:

<zoom>
1...4
Selects the zoom window.
If you turn off one of the zoom windows, all subsequent zoom windows move up one position.

Parameters:

<State>
ON | OFF

*RST: OFF

9.11 Status Registers

The WLAN application uses the standard status registers of the R&S FSW (depending on the measurement type). However, some registers are used differently. Only those differences are described in the following sections.

For details on the common R&S FSW status registers refer to the description of remote control basics in the R&S FSW User Manual.

*RST does not influence the status registers.

- The STATus:QUEStionable:SYNC Register....224
- Querying the Status Registers....225

9.11.1 The STATus:QUEStionable:SYNC Register

The `STATus:QUEStionable:SYNC` register contains application-specific information about synchronization errors or errors during pilot symbol detection. If any errors occur in this register, the status bit #11 in the `STATus:QUEStionable` register is set to 1.

Each active channel uses a separate `STATus:QUEStionable:SYNC` register. Thus, if the status bit #11 in the `STATus:QUEStionable` register indicates an error, the error may have occurred in any of the channel-specific `STATus:QUEStionable:SYNC` registers. In this case, you must check the register of each channel to determine which channel caused the error. By default, querying the status of a register always returns the result for the currently selected channel. However, you can specify any other channel name as a query parameter.

Table 9-15: Meaning of the bits used in the STATus:QUEStionable:SYNC register

Bit No.	Meaning
0	PPDU not found This bit is set if an IQ measurement is performed and no PPDUs are detected
1	This bit is not used
2	No PPDUs of REQuired type This bit is set if an IQ measurement is performed and no PPDUs of the specified type are detected
3	GATE length too small This bit is set if gating is used in a measurement and the gate length is not set sufficiently large enough
4	PPDU count too small This bit is set if a PVT measurement is performed with gating active and there is not at least 1 PPDU within the gate lines
5	Auto level OVERload This bit is set if a signal overload is detected when an auto-level measurement is performed
6	Auto level NoSIGnal This bit is set if no signal is detected by the auto-level measurement
7 - 14	These bits are not used.
15	This bit is always 0.

9.11.2 Querying the Status Registers

The following commands are required to query the status of the R&S FSW and the WLAN application.

For details on the common R&S FSW status registers refer to the description of remote control basics in the R&S FSW User Manual.

- General Status Register Commands....226
- Reading Out the EVENt Part....226
- Reading Out the CONDition Part....226
- Controlling the ENABle Part....227
- Controlling the Negative Transition Part....227
- Controlling the Positive Transition Part....228

9.11.2.1 General Status Register Commands

STATus:PRESet....226
STATus:QUEue[:NEXT]?....226

STATus:PRESet

This command resets the edge detectors and `ENABle` parts of all registers to a defined value. All `PTRansition` parts are set to `FFFFh`, i.e. all transitions from 0 to 1 are detected. All `NTRansition` parts are set to 0, i.e. a transition from 1 to 0 in a `CONDition` bit is not detected. The `ENABle` part of the `STATus:OPERation` and `STATus:QUEStionable` registers are set to 0, i.e. all events in these registers are not passed on.

Usage: Event

STATus:QUEue[:NEXT]?

This command queries the most recent error queue entry and deletes it.

Positive error numbers indicate device-specific errors, negative error numbers are error messages defined by SCPI. If the error queue is empty, the error number 0, "No error", is returned.

Usage: Query only

9.11.2.2 Reading Out the EVENt Part

STATus:OPERation[:EVENt]?
STATus:QUEStionable[:EVENt]?
STATus:QUEStionable:ACPLimit[:EVENt]? <ChannelName>
STATus:QUEStionable:LIMit<n>[:EVENt]? <ChannelName>
STATus:QUEStionable:SYNC[:EVENt]? <ChannelName>

This command reads out the EVENt section of the status register.

The command also deletes the contents of the EVENt section.

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

9.11.2.3 Reading Out the CONDition Part

STATus:OPERation:CONDition?
STATus:QUEStionable:CONDition?
STATus:QUEStionable:ACPLimit:CONDition? <ChannelName>

STATus:QUEStionable:LIMit<n>:CONDition? <ChannelName>
STATus:QUEStionable:SYNC:CONDition? <ChannelName>

This command reads out the CONDition section of the status register.

The command does not delete the contents of the EVENt section.

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

9.11.2.4 Controlling the ENABle Part

STATus:OPERation:ENABle <SumBit>
STATus:QUEStionable:ENABle <SumBit>
STATus:QUEStionable:ACPLimit:ENABle <SumBit>,<ChannelName>
STATus:QUEStionable:LIMit<n>:ENABle <SumBit>,<ChannelName>
STATus:QUEStionable:SYNC:ENABle <BitDefinition>, <ChannelName>

This command controls the ENABle part of a register.

The ENABle part allows true conditions in the EVENt part of the status register to be reported in the summary bit. If a bit is 1 in the enable register and its associated event bit transitions to true, a positive transition will occur in the summary bit reported to the next higher level.

Parameters:

<BitDefinition> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

9.11.2.5 Controlling the Negative Transition Part

STATus:OPERation:NTRansition <SumBit>
STATus:QUEStionable:NTRansition <SumBit>
STATus:QUEStionable:ACPLimit:NTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:LIMit<n>:NTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:SYNC:NTRansition <BitDefinition>,<ChannelName>

This command controls the Negative TRansition part of a register.

Setting a bit causes a 1 to 0 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Parameters:

<BitDefinition> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

9.11.2.6 Controlling the Positive Transition Part

STATus:OPERation:PTRansition <SumBit>
STATus:QUEStionable:PTRansition <SumBit>
STATus:QUEStionable:ACPLimit:PTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:LIMit<n>:PTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:SYNC:PTRansition <BitDefinition>,<ChannelName>

These commands control the Positive TRansition part of a register.

Setting a bit causes a 0 to 1 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Parameters:
<BitDefinition> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

9.12 Commands for Compatibility

The following commands are provided only for compatibility to remote control programs from WLAN applications on previous signal analyzers. For new remote control programs use the specified alternative commands.

The `CONF:BURS:<ResultType>:IMM` commands used in former R&S Signal and Spectrum Analyzers to change the result display are still supported for compatibility reasons; however they have been replaced by the `LAY:ADD:WIND` commands in the R&S FSW (see chapter 9.7, "Configuring the Result Display", on page 184). Note that the `CONF:BURS:<ResultType>:IMM` commands change the screen layout to display the Magnitude Capture buffer in window 1 at the top of the screen and the selected result type in window 2 below that.

MMEMory:LOAD:SEM:STATe....228
[SENSe:]DEMod:FORMat:BANalyze:BTYPe....229
TRIGger[:SEQuence]:MODE....229

MMEMory:LOAD:SEM:STATe <1>, <Filename>

This command loads a spectrum emission mask setup from an xml file.

Note that this command is maintained for compatibility reasons only. Use the `SENS:ESP:PRES` command for new remote control programs.

See the R&S FSW User Manual, "Remote commands for SEM measurements" chapter.

Parameters:
<1>

<Filename> string
Path and name of the `.xml` file that contains the SEM setup information.

Example:
```
MMEM:LOAD:SEM:STAT 1,
'..\sem_std\WLAN\802_11a\802_11a_10MHz_5GHz_band.XML'
```

[SENSe:]DEMod:FORMat:BANalyze:BTYPe <PPDUType>

This remote control command specifies the type of PPDU to be analyzed. Only PPDUs of the specified type take part in measurement analysis.

Note that this command is maintained for compatibility reasons only. Use the specified commands for new remote control programs (see `[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 169 and `[SENSe:]BANDwidth:CHANnel:AUTO:TYPE` on page 166).

Parameters:
<PPDUType>

'MM20'
IEEE 802.11n, Mixed Mode, 20 MHz sampling rate
For new programs use:
```
[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE
MMIX
[SENSe:]BANDwidth:CHANnel:AUTO:TYPE MB20
```

'GFM20'
IEEE 802.11n Green Field Mode, 20 MHz sampling rate
For new programs use:
```
[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE
MGRF
[SENSe:]BANDwidth:CHANnel:AUTO:TYPE MB20
```

TRIGger[:SEQuence]:MODE <Source>

Defines the trigger source.

Note that this command is maintained for compatibility reasons only. Use the `TRIGger[:SEQuence]:SOURce` on page 156 commands for new remote control programs.

This command configures how triggering is to be performed.

Parameters:
<Source>
IMMediate | EXTernal | VIDeo | RFPower | IFPower | TV | AF | AM | FM | PM | AMRelative | LXI | TIME | SLEFt | SRIGht | SMPX | SMONo | SSTereo | SRDS | SPILot | BBPower | MASK | PSENsor | TDTRigger | IQPower | EXT2 | EXT3

A Annex: Reference

A.1 Sample Rate and Maximum Usable I/Q Bandwidth for RF Input

Definitions

- **Input sample rate (ISR)**: the sample rate of the useful data provided by the connected instrument to the R&S FSW input
- (User, Output) **Sample rate (SR)**: the sample rate that is defined by the user (e.g. in the "Data Aquisition" dialog box in the "I/Q Analyzer" application) and which is used as the basis for analysis or output
- **Usable I/Q (Analysis) bandwidth**: the bandwidth range in which the signal remains undistorted in regard to amplitude characteristic and group delay; this range can be used for accurate analysis by the R&S FSW

For the I/Q data acquisition, digital decimation filters are used internally. The passband of these digital filters determines the *maximum usable I/Q bandwidth*. In consequence, signals within the usable I/Q bandwidth (passband) remain unchanged, while signals outside the usable I/Q bandwidth (passband) are suppressed. Usually, the suppressed signals are noise, artifacts, and the second IF side band. If frequencies of interest to you are also suppressed, you should try to increase the output sample rate, since this increases the maximum usable I/Q bandwidth.

Bandwidth extension options

The maximum usable I/Q bandwidth provided by the R&S FSW in the basic installation can be extended by additional options. These options can either be included in the initial installation (B-options) or updated later (U-options). The maximum bandwidth provided by the individual option is indicated by its number, for example, B80 extends the bandwidth to 80 MHz.

Note that the U-options as of U40 always require all lower-bandwidth options as a prerequisite, while the B-options already include them.

Max. usable I/Q BW	Required B-option	Required U-option(s)
10 MHz	-	-
28 MHz	B28	U28
40 MHz	B40	U28+U40 **or** B28+U40
The bandwidth extension option R&S FSW-B320/-U320 requires a reference board revision 3.14 or higher.		

Max. usable I/Q BW	Required B-option	Required U-option(s)
80 MHz	B80	U28+U40+U80 **or** B28+U40+U80 **or** B40+U80
160 MHz	B160	U28+U40+U80+U160 **or** B28+U40+U80+U160 **or** B40+U80+U160 **or** B80+U160
320 MHz	B320*)	U28+U40+U80+U160+U320 **or** B28+U40+U80+U160+U320 **or** B40+U80+U160+U320 **or** B80+U160+U320 **or** B160+U320
The bandwidth extension option R&S FSW-B320/-U320 requires a reference board revision 3.14 or higher.		

As a rule, the usable I/Q bandwidth is proportional to the output sample rate. Yet, when the I/Q bandwidth reaches the bandwidth of the analog IF filter (at very high output sample rates), the curve breaks.

Relationship between sample rate and usable I/Q bandwidth

Up to the maximum bandwidth, the following rule applies:

*Usable I/Q bandwidth = 0.8 * Output sample rate*

The figure 1-1 shows the maximum usable I/Q bandwidths depending on the output sample rates.

R&S FSW without additional bandwidth extension options

sample rate: 100 Hz - 10 GHz

maximum I/Q bandwidth: 10 MHz

Sample rate	Maximum I/Q bandwidth
100 Hz to 10 MHz	proportional up to maximum 10 MHz
10 MHz to 10 GHz	10 MHz

R&S FSW with options B28 or U28 (I/Q Bandwidth Extension):

sample rate: 100 Hz - 10 GHz

maximum bandwidth: 28 MHz

Sample rate	Maximum I/Q bandwidth
100 Hz to 35 MHz	proportional up to maximum 28 MHz
35 MHz to 10 GHz	28 MHz

R&S FSW with option B40 or U40 (I/Q Bandwidth Extension):

sample rate: 100 Hz - 10 GHz

maximum bandwidth: 40 MHz

Sample rate	Maximum I/Q bandwidth
100 Hz to 50 MHz	proportional up to maximum 40 MHz
50 MHz to 10 GHz	40 MHz

R&S FSW with option B80 or U80 (I/Q Bandwidth Extension):

sample rate: 100 Hz - 10 GHz

maximum bandwidth: 80 MHz

Sample rate	Maximum I/Q bandwidth
100 Hz to 100 MHz	proportional up to maximum 80 MHz
100 MHz to 10 GHz	80 MHz

R&S FSW with activated option B160 or U160 (I/Q Bandwidth Extension):

sample rate: 100 Hz - 10 GHz

maximum bandwidth: 160 MHz

Sample rate	Maximum I/Q bandwidth
100 Hz to 200 MHz	proportional up to maximum 160 MHz
200 MHz to 10 GHz	160 MHz

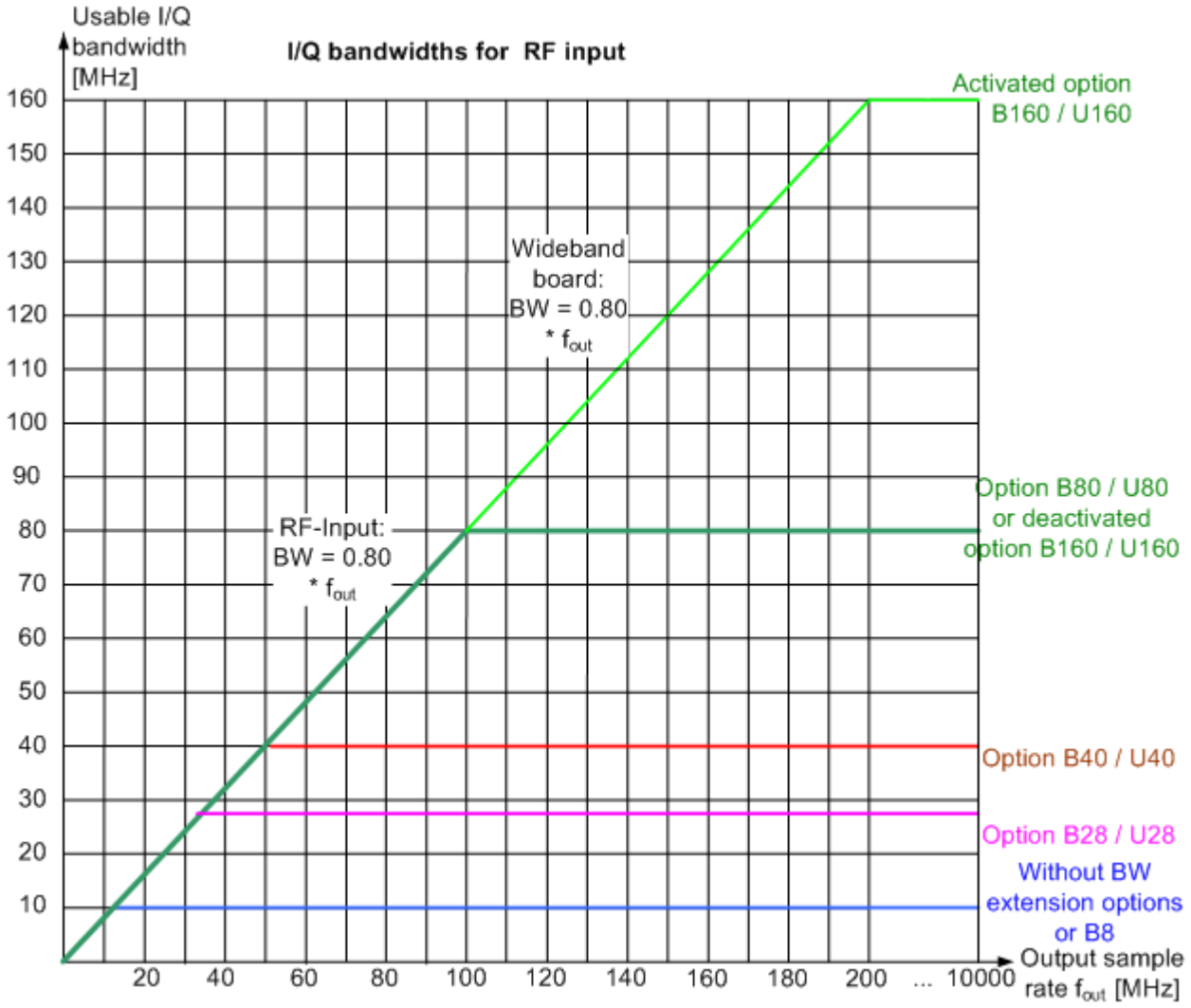


Fig. 1-1: Relationship between maximum usable I/Q bandwidth and output sample rate with and without bandwidth extensions

R&S FSW with activated option B320 or U320 (I/Q Bandwidth Extension):

sample rate: 100 Hz - 10 GHz

maximum bandwidth: 320 MHz

Sample rate	Maximum I/Q bandwidth
100 Hz to 400 MHz	proportional up to maximum 320 MHz
400 MHz to 10 GHz	320 MHz

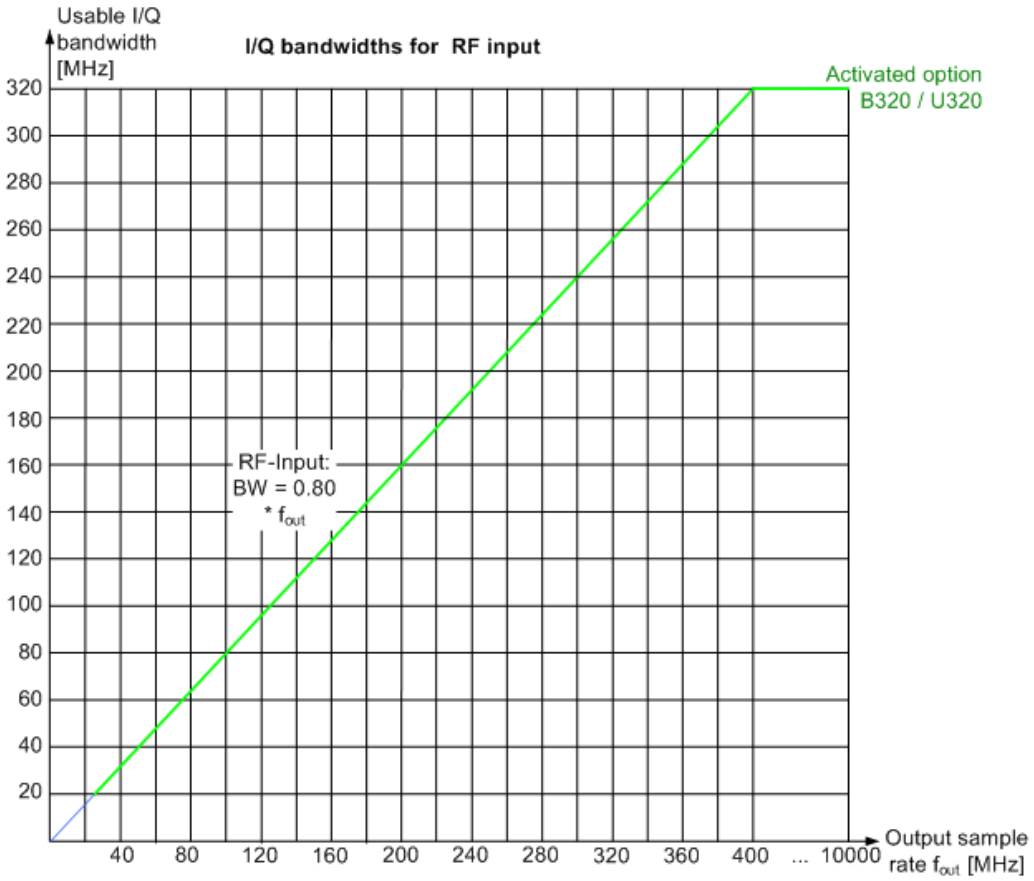


Fig. 1-2: Relationship between maximum usable I/Q bandwidth and output sample rate for active R&S FSW-B320

A.2 I/Q Data File Format (iq-tar)

I/Q data is packed in a file with the extension `.iq.tar`. An iq-tar file contains I/Q data in binary format together with meta information that describes the nature and the source of data, e.g. the sample rate. The objective of the iq-tar file format is to separate I/Q data from the meta information while still having both inside one file. In addition, the file format allows you to preview the I/Q data in a web browser, and allows you to include user-specific data.

The iq-tar container packs several files into a single `.tar` archive file. Files in `.tar` format can be unpacked using standard archive tools (see http://en.wikipedia.org/wiki/Comparison_of_file_archivers) available for most operating systems. The advantage of `.tar` files is that the archived files inside the `.tar` file are not changed (not compressed) and thus it is possible to read the I/Q data directly within the archive without the need to unpack (untar) the `.tar` file first.

Sample iq-tar files

If you have the optional R&S FSW VSA application (R&S FSW-K70), some sample iq-tar files are provided in the `C:/R_S/Instr/user/vsa/DemoSignals` directory on the R&S FSW.

Contained files

An iq-tar file must contain the following files:

- **I/Q parameter XML file**, e.g. `xyz.xml`
  Contains meta information about the I/Q data (e.g. sample rate). The filename can be defined freely, but there must be only one single I/Q parameter XML file inside an iq-tar file.
- **I/Q data binary file**, e.g. `xyz.complex.float32`
  Contains the binary I/Q data of all channels. There must be only one single I/Q data binary file inside an iq-tar file.

Optionally, an iq-tar file can contain the following file:

- **I/Q preview XSLT file**, e.g. `open_IqTar_xml_file_in_web_browser.xslt`
  Contains a stylesheet to display the I/Q parameter XML file and a preview of the I/Q data in a web browser.
  A sample stylesheet is available at http://www.rohde-schwarz.com/file/open_IqTar_xml_file_in_web_browser.xslt.

A.2.1 I/Q Parameter XML File Specification

The content of the I/Q parameter XML file must comply with the XML schema `RsIqTar.xsd` available at: http://www.rohde-schwarz.com/file/RsIqTar.xsd.

In particular, the order of the XML elements must be respected, i.e. iq-tar uses an "ordered XML schema". For your own implementation of the iq-tar file format make sure to validate your XML file against the given schema.

The following example shows an I/Q parameter XML file. The XML elements and attributes are explained in the following sections.

Sample I/Q parameter XML file: xyz.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl"
href="open_IqTar_xml_file_in_web_browser.xslt"?>
<RS_IQ_TAR_FileFormat fileFormatVersion="1"
xsi:noNamespaceSchemaLocation="RsIqTar.xsd"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <Name>FSV-K10</Name>
  <Comment>Here is a comment</Comment>
  <DateTime>2011-01-24T14:02:49</DateTime>
  <Samples>68751</Samples>
  <Clock unit="Hz">6.5e+006</Clock>
```

```
  <Format>complex</Format>
  <DataType>float32</DataType>
  <ScalingFactor unit="V">1</ScalingFactor>
  <NumberOfChannels>1</NumberOfChannels>
<DataFilename>xyz.complex.float32</DataFilename>
<UserData>
  <UserDefinedElement>Example</UserDefinedElement>
</UserData>
  <PreviewData>...</PreviewData>
</RS_IQ_TAR_FileFormat>
```

Element	Description
RS_IQ_TAR_File-Format	The root element of the XML file. It must contain the attribute `fileFormatVersion` that contains the number of the file format definition. Currently, `fileFormatVersion` "2" is used.
Name	Optional: describes the device or application that created the file.
Comment	Optional: contains text that further describes the contents of the file.
DateTime	Contains the date and time of the creation of the file. Its type is `xs:dateTime` (see `RsIqTar.xsd`).
Samples	Contains the number of samples of the I/Q data. For multi-channel signals all channels have the same number of samples. One sample can be: • A complex number represented as a pair of I and Q values • A complex number represented as a pair of magnitude and phase values • A real number represented as a single real value See also `Format` element.
Clock	Contains the clock frequency in Hz, i.e. the sample rate of the I/Q data. A signal generator typically outputs the I/Q data at a rate that equals the clock frequency. If the I/Q data was captured with a signal analyzer, the signal analyzer used the clock frequency as the sample rate. The attribute `unit` must be set to "Hz".
Format	Specifies how the binary data is saved in the I/Q data binary file (see `DataFilename` element). Every sample must be in the same format. The format can be one of the following: • `complex`: Complex number in cartesian format, i.e. I and Q values interleaved. I and Q are unitless • `real`: Real number (unitless) • `polar`: Complex number in polar format, i.e. magnitude (unitless) and phase (rad) values interleaved. Requires `DataType` = `float32` or `float64`
DataType	Specifies the binary format used for samples in the I/Q data binary file (see `DataFilename` element and chapter A.2.2, "I/Q Data Binary File", on page 238). The following data types are allowed: • `int8`: 8 bit signed integer data • `int16`: 16 bit signed integer data • `int32`: 32 bit signed integer data • `float32`: 32 bit floating point data (IEEE 754) • `float64`: 64 bit floating point data (IEEE 754)

Element	Description
ScalingFactor	Optional: describes how the binary data can be transformed into values in the unit Volt. The binary I/Q data itself has no unit. To get an I/Q sample in the unit Volt the saved samples have to be multiplied by the value of the `ScalingFactor`. For polar data only the magnitude value has to be multiplied. For multi-channel signals the `ScalingFactor` must be applied to all channels. The attribute `unit` must be set to "`V`". The `ScalingFactor` must be > 0. If the `ScalingFactor` element is not defined, a value of 1 V is assumed.
NumberOfChannels	Optional: specifies the number of channels, e.g. of a MIMO signal, contained in the I/Q data binary file. For multi-channels, the I/Q samples of the channels are expected to be interleaved within the I/Q data file (see chapter A.2.2, "I/Q Data Binary File", on page 238). If the `NumberOfChannels` element is not defined, one channel is assumed.
DataFilename	Contains the filename of the I/Q data binary file that is part of the iq-tar file. It is recommended that the filename uses the following convention: <xyz>.<Format>.<Channels>ch.<Type> • <xyz> = a valid Windows file name • <Format> = complex, polar or real (see `Format` element) • <Channels> = Number of channels (see `NumberOfChannels` element) • <Type> = float32, float64, int8, int16, int32 or int64 (see `DataType` element) Examples: • xyz.complex.1ch.float32 • xyz.polar.1ch.float64 • xyz.real.1ch.int16 • xyz.complex.16ch.int8
UserData	Optional: contains user, application or device-specific XML data which is not part of the iq-tar specification. This element can be used to store additional information, e.g. the hardware configuration. User data must be valid XML content.
PreviewData	Optional: contains further XML elements that provide a preview of the I/Q data. The preview data is determined by the routine that saves an iq-tar file (e.g. R&S FSW). For the definition of this element refer to the `RsIqTar.xsd` schema. Note that the preview can be only displayed by current web browsers that have JavaScript enabled and if the XSLT stylesheet `open_IqTar_xml_file_in_web_browser.xslt` is available.

Example: ScalingFactor

Data stored as `int16` and a desired full scale voltage of 1 V

`ScalingFactor` = 1 V / maximum int16 value = 1 V / 2^{15} = 3.0517578125e-5 V

Scaling Factor	Numerical value	Numerical value x ScalingFactor
Minimum (negative) int16 value	- 2^{15} = - 32768	-1 V
Maximum (positive) int16 value	2^{15}-1= 32767	0.999969482421875 V

Example: PreviewData in XML

```
<PreviewData>
    <ArrayOfChannel length="1">
      <Channel>
        <PowerVsTime>
          <Min>
```

```
        <ArrayOfFloat length="256">
          <float>-134</float>
          <float>-142</float>
          ...
          <float>-140</float>
        </ArrayOfFloat>
      </Min>
      <Max>
        <ArrayOfFloat length="256">
          <float>-70</float>
          <float>-71</float>
          ...
          <float>-69</float>
        </ArrayOfFloat>
      </Max>
    </PowerVsTime>
    <Spectrum>
      <Min>
        <ArrayOfFloat length="256">
          <float>-133</float>
          <float>-111</float>
          ...
          <float>-111</float>
        </ArrayOfFloat>
      </Min>
      <Max>
        <ArrayOfFloat length="256">
          <float>-67</float>
          <float>-69</float>
          ...
          <float>-70</float>
          <float>-69</float>
        </ArrayOfFloat>
      </Max>
    </Spectrum>
    <IQ>
      <Histogram width="64" height="64">0123456789...0</Histogram>
    </IQ>
  </Channel>
 </ArrayOfChannel>
</PreviewData>
```

A.2.2 I/Q Data Binary File

The I/Q data is saved in binary format according to the format and data type specified in the XML file (see `Format` element and `DataType` element). To allow reading and writing of streamed I/Q data, all data is interleaved, i.e. complex values are interleaved pairs of I and Q values and multi-channel signals contain interleaved (complex) samples for

channel 0, channel 1, channel 2 etc. If the `NumberOfChannels` element is not defined, one channel is presumed.

Example: Element order for real data (1 channel)

```
I[0],                       // Real sample 0
I[1],                       // Real sample 1
I[2],                       // Real sample 2
...
```

Example: Element order for complex cartesian data (1 channel)

```
I[0], Q[0],                 // Real and imaginary part of complex sample 0
I[1], Q[1],                 // Real and imaginary part of complex sample 1
I[2], Q[2],                 // Real and imaginary part of complex sample 2
...
```

Example: Element order for complex polar data (1 channel)

```
Mag[0], Phi[0],             // Magnitude and phase part of complex sample 0
Mag[1], Phi[1],             // Magnitude and phase part of complex sample 1
Mag[2], Phi[2],             // Magnitude and phase part of complex sample 2
...
```

Example: Element order for complex cartesian data (3 channels)

Complex data: I[channel no][time index], Q[channel no][time index]

```
I[0][0], Q[0][0],           // Channel 0, Complex sample 0
I[1][0], Q[1][0],           // Channel 1, Complex sample 0
I[2][0], Q[2][0],           // Channel 2, Complex sample 0

I[0][1], Q[0][1],           // Channel 0, Complex sample 1
I[1][1], Q[1][1],           // Channel 1, Complex sample 1
I[2][1], Q[2][1],           // Channel 2, Complex sample 1

I[0][2], Q[0][2],           // Channel 0, Complex sample 2
I[1][2], Q[1][2],           // Channel 1, Complex sample 2
I[2][2], Q[2][2],           // Channel 2, Complex sample 2
...
```

Example: Element order for complex cartesian data (1 channel)

This is an example of how to store complex cartesian data in float32 format using MATLAB®.

```
% Save vector of complex cartesian I/Q data, i.e. iqiqiq...
N = 100
iq = randn(1,N)+1j*randn(1,N)
fid = fopen('xyz.complex.float32','w');
for k=1:length(iq)
  fwrite(fid,single(real(iq(k))),'float32');
```

```
  fwrite(fid,single(imag(iq(k))),'float32');
end
fclose(fid)
```

List of Remote Commands (WLAN)

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